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CONTENTS

(Vol. XV. Part III.)

ORIGINAL ARTICLES

SELECTED ARTICLES

NOTES

LIST OF ILLUSTRATIONS

The following Original Articles will appear in our next issue (July 1920).

Original Articles

SOME COMMON INDIAN BIRDS.

No. 3. THE SPOTTED OWLET (*ATHENE BRAMA*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist;

AND

C. M. INGLIS, M.B.O.U., F.Z.S.

Of the two score or so of species of owls which are found within Indian limits, the Spotted Owlet (*Athene brama*) is probably at once the commonest and most familiar, as it occurs abundantly throughout the Plains of India and Burma (although not found in Ceylon) and is in evidence during the early evening often before sunset and long before dusk, when most other owls have not yet ventured out. It is, moreover, quite a domestic owl, keeping especially to trees in cultivated tracts such as gardens around houses, and it is commonly found roosting and breeding in the roofs of houses where these afford the necessary shelter. It is fond of perching on the branch of a tree or on a pole or fence or telegraph-wire; indeed, as Hume remarks, it is one of the birds that seem to think that telegraph-wires were erected for their sole and especial benefit. It is a decidedly noisy bird, making itself most evident to the ear in the evening or early morning, but frequently heard at intervals during the night, when a regular volley of

chuckles and squeaks is poured forth by one or more of these little owlets; but the noise is not sustained for any length of time.

In the daytime, like other owls, the Spotted Owlet hides away in some dark corner, such as a hole in a tree or wall or in a house-roof or even in a bungalow verandah if no better situation offers, emerging towards sunset to hunt for prey. As Cunningham remarks, it is most diverting to watch them emerging; one after another, before fairly coming out, putting forth its queer little round head and staring eyes through the opening of the cavern. After they have emerged they usually sit very quietly for a time as though only half awake, and are either perfectly silent or occasionally utter a low-toned "chirrk." Then, all of a sudden, they begin to chuckle and finally break out into a perfect torrent of hoarse chattering; and finally, after having indulged in such exercises for some minutes, they spread their short, rounded wings and sail off to their night's hunting.

However, it does not seem to mind the full blaze and heat of the sun, as we have seen it in the early afternoon on a hot April day sunning itself with outspread wings on the bare gravel in front of the bungalow. A pair which have for years inhabited the bungalow of one of us (C. M. I.) may often be seen during the daytime either perched on some *sambhar's* antlers on the verandah wall or else flying with undulating flight to a tree in the garden, usually to a tamarind tree, and, after staying there a short time, returning to their hole. We have also seen them on a drizzly day seated on a perch outside, enjoying a shower bath.

It is one of the birds that hawk termites (white ants, so called) along with Rollers, etc. Mr. Stuart Baker writes that they are great bat hunters, not catching them on the wing but hauling them out of their holes; but apparently all these owls do not wage war against bats and this habit is perhaps local or confined to a few individuals.

It lives chiefly on insects and to a less extent on mice, shrews and lizards, its insect prey consisting mostly of beetles and crickets. In the case of eight birds examined at Pusa by the late C. W. Mason, of 69 insects taken, one was of a beneficial species, twenty-six were

neutral and forty-two were injurious. Hume mentions a case, reported by Colonel Butler, in which a pair of Spotted Owlets had apparently attacked a nesting Paroquet (*P. torquatus*), killed it on the nest and taken possession of this for themselves. As the Paroquet is a perfect pest to the agriculturist, we can only wish that the Spotted Owlet would act regularly in this way. At Pusa this little owl seems to live largely on large crickets (*Brachytrypes* and *Gryllotalpa*) and on dung-beetles. There is no doubt that it is a most useful bird in all districts where large crickets occur so commonly as to do damage. As these crickets are nocturnal, retreating into their subterranean burrows during the daytime and only emerging to feed under cover of night, their most effective natural enemies are those, such as the Spotted Owlet, which are also nocturnal and which can swoop down and destroy them whilst they are feeding above-ground. One commonly sees this little owl swoop down from its perch and catch some prey on the ground, returning to its perch to devour it, usually to the accompaniment of a burst of chattering which is presumably its form of thank-offering for a good supper.

Our Plate gives a good idea of this little owl and the left-hand figure shows the terrifying attitude, assumed, after first sitting up very erect, by suddenly crouching down and frowning and glaring in a terrible way, to frighten any observer or intruder.

The Spotted Owlet breeds from February to April, the period being slightly earlier in the South and later in Northern India, but the great majority of birds lay in March, laying usually three, four or five white (pink when fresh) eggs in a hole, in a tree or building, the nest being scantily lined with a few dry leaves, grass, decayed wood, or feathers. We have taken three clutches of three eggs each from one nest but even then the birds would not desert their nesting site. Incubation evidently starts as soon as the bird lays as we have taken at the same time from one nest one young, two highly incubated and one perfectly fresh egg. The fluffy young, when fledged, are drab-and-white with yellow eyes just like their parents and, also like their parents, are exceedingly noisy, each member of the family, as Dewar puts it, talking gibberish at the

top of its voice, sixteen to the dozen, and as all will persist in speaking at once, the result is a nocturnal chorus that will bear comparison with the efforts of the cats which enliven the Londoner's back yard.

Jerdon, quoting Sykes, writes that "the Mahrattas have a superstition regarding this species, and a class of people called *Pingleh* live on the credibility of the people by pretending to consult it and predict events." Jerdon also says that this Owlet is used by some *shikaris* to catch small birds. It is pegged out near a low bush, the branches of which have been smeared with bird-lime, so that any small birds that come to mob it settle on the bush and are caught on the limed twigs. It is, however, noticeable that this owl does not seem to be molested by birds, as other larger owls are, probably because it is more at home in daylight and so does not attract notice by the blundering flight assumed by other owls when they venture out by day. Its flight is indeed far from a blundering one and, in a recent issue of the Bombay Natural History Society's Journal, Mr. G. O. Allen has called attention to its occasional habit of hovering; this we have also noticed at times and it is probably assumed when watching some small prey which has emerged from its burrow.

THE POSSIBILITIES OF AGRICULTURE IN INDIA WITHIN THE NEXT TWENTY YEARS.*

BY

D. CLOUSTON, C.I.E., M.A., B.Sc.,

Director of Agriculture, Central Provinces and Berar.

I HAVE to extend to you a hearty welcome to this meeting of the Agriculture and Applied Botany Section of the Indian Science Congress. I very much appreciate the honour of being asked to preside over this section. The subject on which I am to address you is one which will, I trust, be of interest to many here; for most of us are beginning to realize how potent a factor science is in the development of India's greatest industry—agriculture.

It has been said that in the career of a department, as in the life of a man, there are stages from which it is appropriate to take a glance backward and to contemplate the outlook of the future. Prophesy being the rôle of science, I am to play the part of a prophet on this occasion in so far as I shall, in the light of the progress already made in developing agriculture in India, try to give some indication of the rate of advancement to be looked for in future.

At the present stage of advancement a study of the history of agricultural development in England, where many of the difficulties were experienced which we are up against in India to-day, may prove helpful. Till the latter part of the eighteenth century the agricultural unit in Great Britain was the village with its scattered holdings, common grazing grounds, half-starved cattle and poor crops resulting from bad cultivation, which are so characteristic of many parts of India at the present day. Many improvements

* Presidential Address to the Agricultural Section of the Seventh Indian Science Congress, Nagpur, 1920.

had been introduced before that time; the more enterprising farmers had learnt, for example, how to grow turnips, clover, artificial grasses and other fodder crops, how to avoid the need of fallows by adopting suitable rotations, and how to grow crops in line by using seed drills for sowing and hoes for interculture. These improvements were, however, not generally adopted for many years because of the difficulty of protecting such fodder crops in villages which had not been enclosed.

The Napoleonic wars and the rapid development of our manufacturing industries in the latter years of the eighteenth century and the early part of the nineteenth gave a great impetus to English agriculture by forcing up prices of farm produce. High prices, coupled with a rise in the cost of labour, encouraged the use of labour-saving appliances and the production of larger acreage outturns. The open field system of scattered holdings with its bad cultivation which resulted therefrom began to give way slowly before economic pressure and the more intensive methods of farming which began to be adopted by the leading "gentlemen" farmers of the land. Consolidated holdings were fenced and the cultivation of turnips, clover and other new crops, which were to revolutionize farming, were taken up on a larger scale than ever before. Progress, however, was not so rapid as it might have been, as most of our English farmers of this period, like their fathers before them, stuck to their empirical methods based on old use and wont; for there was as yet no science of agriculture which could be applied to the solution of its manifold problems. Such advancement as was made in those days can be directly attributed to the interest taken in improved husbandry by men like Jethro Tull, Bakewell, Lord Townsend and Arthur Young who, though not themselves scientists in our sense of the term, possessed the scientific habit of mind which they brought to bear on the agricultural problems of the day.

Science began to be applied systematically to the development of the agricultural resources of England about the middle of the nineteenth century, and with very beneficial results. By better breeding and better feeding, her breeds of cattle, sheep and horses were improved out of all resemblance to their progenitors; Great Britain

became the world's stud farm. Labour-saving machinery and better methods of cultivation were rapidly introduced and improved strains of seed raised. More attention was given to the improvement of the soil by drainage and manuring, to the protection of crops from cattle, and to the better housing of live stock. As a result of the improvements effected, the acreage yield of the staple crops and the average weight of cattle and sheep were more than doubled. These and other improvements introduced in the latter half of the last century have added largely to the material welfare of the English farmer. Development would have been much more rapid however, had her statesmen fully realized the enormous possibilities there were of agriculture being benefited by experiment and research. For the splendid progress that was made we are largely indebted to the great work done by scientists like Lawes and Gilbert; to enterprising seedsmen like Garton and Sutton; to the ingenuity of manufacturing firms which vied with each other in designing machinery suitable for the farm; and to the fine example of the larger farmers who were in a position to utilize to the full the modern developments of organization and scientific knowledge.

As a result of the exigencies of the great war now happily ended, scientific enquiry in all branches of industry has, since 1914, been stimulated to an extraordinary extent. Never before has the value of agricultural science had such recognition. Statesmen and the public generally have come to realize the paramount importance of providing for the endowment of work connected with the development of agriculture on a scale commensurate with its great importance, because they now see, as they never did before, that "the countries which have made the greatest progress and which obtain from their soil the highest returns are those which have increased their research institutions." Denmark was obliged to do so after her defeat by Germany in 1863, and has, as the result, been able to increase the acreage outturns of her staple crops by 24 per cent. in the short space of a little over 50 years. Germany, foreseeing the possibility of being blockaded by the British fleet in the event of a war with our country, had, for 40 years previous to the outbreak of war, been studiously organizing her institutions for experiment and

research in agriculture, with the result that, when war broke out, her resisting power came as a most unwelcome surprise to the allies, who had hoped to sap her strength by starvation.

Let us now consider the position of agriculture in India and the possibility of our benefiting from the experience gained in other countries. The economic conditions which obtain at the present time in India resemble in many respects those which stimulated agriculture in England in the early part of the nineteenth century. A great war has again forced up the prices of farm produce to an abnormal figure. The industries of this country are being developed with phenomenal rapidity. The cost of farm labour is rising and will continue to rise, for the new industries will continue to draw workers from rural areas. If they are to take full advantage of the golden opportunities which are now offered them, landholders in this country will have to use labour-saving machinery on a much larger scale than formerly, and they will be obliged to adopt more intensive methods of cultivation all round, involving manuring and irrigation on a large scale. So long as prices remain at their present high level intensive cultivation will pay handsomely. Manures, for instance, which were applied at a loss five years ago, can now be applied at a handsome profit. The present favourable position of the market for agricultural produce marks, in short, the beginning of an era of prosperity for the cultivator if he will but take advantage of his opportunities. He will have, however, to re-adjust in many ways his system of agriculture. To be successful he will have to put more brains, energy and capital into his work; and in this we hope that the larger landowners will, like the "gentlemen" farmers of England of days of yore, take the lead in restripping and consolidating their holdings, and in developing the capacities of their own estates. It will be the duty of the department of agriculture to play its part by placing at their disposal the best possible scientific and practical advice, and in the shortest possible time. I am confident that the Government of this country will play its part well, and that the *laissez-faire* policy, formerly adopted to the detriment of agricultural development in some countries in the West, will not be followed by statesmen in India.

Of the value of the work accomplished by the Department of Agriculture in India within the last 13 or 14 years the Indian Industrial Commission has written as follows:—"The striking financial results which followed quickly and directly after the employment, from about 1905, of scientific specialists in agricultural research, demonstrate the wisdom of investing in modern science." This is the unbiassed opinion of a body of men who had considerable opportunities of studying the facts on which they based their conclusions. The work which the department has already accomplished is undoubtedly adding annually to the farming profits of the country a sum which exceeds its total annual expenditure many times over. The rate of advance, moreover, is likely to be very much greater in the near future than it has been in the past; for we now have a background of exact knowledge available which gives us a most useful basis for future progress. We have behind us, moreover, an enlightened government which has set its seal of approval on the work already accomplished, and which has determined to make ample provision for further expansion.

The achievement which has perhaps appealed most to the public is the introduction of superior varieties and strains of seed of the principal staple crops. To take only three of these, namely, cotton, wheat and rice, there is reason to believe that approximately two and a half million acres of improved varieties of cotton, and one each of wheat and rice, are already being grown. If the extra annual profit accruing from the cultivation of these were only two rupees per acre even, it would mean in the aggregate a total extra profit of approximately 90 lakhs of rupees, which far exceeds the total annual expenditure on all the departments of agriculture in India; but the actual extra profit from the introduction of improved varieties of these three crops is at least four times the amount which I have stated. This, moreover, is only a fraction of what has already been achieved, for the activities of the department now extend over a wide field including not only crop improvements, but the introduction of better and more intensive methods of cultivation all round. The introduction of a one per cent. improvement here and of a two per cent. improvement there is, in the aggregate,

adding largely to the wealth of the cultivator, and is fitting him for further progress. It is evident from what has already been accomplished that the department should, within twenty years, be in a position to introduce improvements which will add many crores of rupees annually to the farming profits of the cultivators.

The extent to which future progress can be guaranteed will very largely depend on the measures adopted by the Government of this country to secure an adequate staff of first class specialists in agriculture and the sciences allied thereto. We want the very best brains which the universities of the West can turn out, to help in the solution of India's agricultural problems, and to help in training Indians for this great work. Nor should time be wasted in getting these, for to train research men and original experimenters effectively takes many years, and such men even when fully trained cannot reasonably be expected to produce results till after years of careful investigation as a rule. Owing to the present shortage of staff our work is being carried on under great difficulties, and progress is retarded thereby. The value of the improvements already effected by a small staff has no doubt been surprisingly great; but let us not forget that up to the present we have tackled only the most obvious lines of improvement. We have merely scratched the surface so to speak; for the new knowledge which is to add tangibly to the profits of the cultivator we shall have to dig deeper. We have not as yet, for instance, given much attention to the question of cattle improvement by better feeding and breeding. Personally I am of opinion that this is one of our most hopeful fields of investigation, and I am confident that wonderful improvements can and will be effected within the next twenty years.

Much has already been accomplished in the way of improving the staple crops of the country by selection and hybridization, and this has paved the way for further improvements by better tillage methods and manuring: but for better cultivation we require better implements. Some thousands of improved ploughs, cane mills and other implements are now in use in rural India; but the existing demand is, I am sure, a mere fraction of what it will be in the near future. It is the duty of the department to see that this growing

demand is met satisfactorily. It is its duty, too, to assist manufacturers in devising suitable implements; to induce agricultural associations and unions to start depôts for the demonstration, sale, hire and repair of types suitable for the tract for which they are required; and to assist purchasers in setting up plants, if necessary. But here again we are at present handicapped for want of a staff of specialists. Some provinces have not yet obtained the services of an Agricultural Engineer, with the result that duties which ordinarily fall to such an expert are entrusted to Deputy Directors, very few of whom have had any training in mechanical engineering. We urgently require for each province an Agricultural Engineer to help to devise and set up improved types of agricultural machinery; and we want to get implements of the type required manufactured on a large scale in this country.

Much of the cultivated land in India has almost reached the maximum state of impoverishment; a great part of the cattle manure, which ought to go back to it, is burnt as fuel; and other available manures have not yet been used extensively. Indian soils over large areas have thus been starved for centuries, and are hungry, and therefore very responsive to manuring. It is largely due to the judicious application of water and manure that the crops obtained on Government farms are so much better as a rule than those of cultivators in adjoining villages. The testing of green manures, oilcakes, bones, fish, mineral manures, etc., and the study of their relation to bacterial life in the soil have been started. The results already obtained indicate the great need there is of inducing the cultivator to do everything in his power to conserve his farmyard manure, and to supplement it by using other available manures such as bones, oilcakes and green manures. In this the department can, and is giving him valuable assistance, by advising him as to the kinds and quantities to apply, and by helping him to organize depôts for the sale of manures which can be used economically. It can assist, too, in establishing fuel reserves for the supply of fuel to villages; for want of such reserves cultivators over the greater part of India are compelled under existing conditions to use the dung of their cattle for fuel. There is no other course open to them at present.

The damage done annually to our staple crops by fungal diseases and insect pests is enormous. Here again we have a promising field of investigation which, for want of staff, we have not as yet been able to explore at all fully. Much has been done no doubt in the way of studying the life-histories of these diseases and pests; but with the limited knowledge at our disposal we are not yet in a position to recommend remedial measures except in a very few cases.

The conditions for fruit-growing in India are most favourable, and the subject is now beginning to get some attention from the department; but here again for want of experts in fruit-growing the work is at present relegated to men who have no special knowledge of the subject. The whole field of agriculture, in short, is still bristling with unsolved problems, which cannot be investigated effectively for want of trained specialists in the different branches of agricultural science involved.

The degree of specialization and of intensive concentration required for sound research in the different sections of the department is not possible at present. The circle of the average Deputy Director of Agriculture, for example, is so large and his duties so manifold that he can devote only a small fraction of his time to experiment and research without which real progress is impossible. From the results already obtained by our botanical experts, who have devoted attention to the improvement of the staple crops, there is but little doubt that it would pay handsomely to employ in each province a sufficient number of first class botanists to deal with all the more important crops; and the number of crops allotted to any one man should not ordinarily exceed two. There are undoubtedly problems enough in each province to occupy the whole time of several such men. To put one man in charge of more work than he can do efficiently is, in short, false economy, and this applies not only to Deputy Directors and Botanists, but to other experts as well. In every section the men employed are too much distracted at present by the great variety of problems which they have to tackle. So long as we are understaffed, moreover, it will be impossible for experts to give their assistants the specialized training

which is so necessary in the interest of efficiency. Farm Superintendents should, for example, be trained in experimentation, plant improvement and other lines of work entrusted to them before they are put in charge of experimental stations; and the men to be put in charge of demonstration and organization work should similarly be specially selected and trained for that class of work.

If we neglect to make adequate provision for experiment and research, we shall sooner or later find ourselves in the position of having nothing new to teach the cultivator; if given an efficient staff on the other hand, there is reason to believe that it will become increasingly easy to get him to adopt our teaching; for as a result of the work which the department has already accomplished his confidence has been gained to some extent, and he is now more willing than ever he was to make use of new ideas. To get that teaching adopted in the shortest possible time, we shall require many more government farms, and a more complete district organization, including taluq agricultural associations and unions, working under the guidance of the department. Each taluq or tahsil of a province should have its own government farm to which cultivators could come for help and advice. From these farms they would get their supplies of improved seeds, manures and implements; and agricultural literature of interest to them might also be stocked there. The taluq farm would be the centre for the meetings of the taluq agricultural association and for agricultural shows. It would be the centre, too, for agricultural education. Each farm might have its own agricultural school where the sons of landholders could be trained in the practice and principles of agriculture. The villages of the taluq might be divided into groups of ten or more, each group constituting an agricultural union which might have its own co-operative shop or depôt for the supply of seeds, implements, manures, agricultural literature, etc. The taluq agricultural association would consist of the office-bearers of these agricultural unions, while the members of the agricultural union would be the representatives of the ten or more villages included in the union. These unions would arrange for the sale and hire of implements in the villages and for the sale and distribution of other articles stocked

in their depôts. Each village of a union might have its own seed farms, its own stud bull or bulls, and its own fuel reserve. To control this organization efficiently it would be necessary to have a managing committee for each district with the Deputy Commissioner as chairman and the Deputy Director of Agriculture as agricultural adviser. The non-official members of the committee might consist of representatives elected every year by the taluq associations. The duty of the committee would be to define the policy to be followed by the taluq associations and unions controlled by them, and to allot funds for the demonstration work carried out by the unions. In order to provide money for this work each union could be called upon to contribute part of its profits to a general fund. District and taluq agricultural agencies organized in this way would be the medium through which legislative measures for the advancement of agriculture and the amelioration of the people would be carried out. Through these agencies one or more model villages with consolidated holdings, sanitary houses, schools, trim fences and serviceable roads could be laid out and run as object-lessons for the whole taluq. A system of demonstration and co-operation run on these lines would, I believe, help to break down the barriers which at present stand in the way of progress.

In conclusion, I would ask whether it is too much to expect that within twenty years the department if adequately staffed will, by patient, concentrated, and intensive investigation, have accumulated a body of knowledge in every branch of agriculture which may benefit India to the extent of many crores of rupees annually. And is it too much to expect that, by working with and through the people, it will be possible to get them to apply that knowledge? In the past the department has had its successes and its failures, but its successes have been far greater than Provincial Governments ever anticipated. An era of still greater accomplishment lies ahead of us. Our successes of the future will, I am confident, surpass our highest expectations. The great task of reconstruction which lies before us is well worth all the energy and brains we can put into it; for on the development of her agriculture depends not only the prosperity of India's many millions of agriculturists, but to a great

extent the lot of those engaged in other industries dependent on agriculture. Increased production will help to banish famine and poverty from the land, and to bring us near the realization of our hope, namely, to make India "a garden ringing with cheerful and contented life, with smiling fields and food in plenty."

SOME ASPECTS OF PLANT GENETICS.*

BY

W. BURNS, D.Sc.

Economic Botanist, Bombay.

ABOUT a month ago I received from the Secretaries of this Congress the invitation to take the place of Professor Fyson of Madras as Chairman of the Botany Section. You will, I am sure, join me in expressing our deep regret that Professor Fyson is prevented by ill-health from joining us. We miss him, and we miss his address, but we hope that on some future occasion we shall have the pleasure and instruction which a pronouncement by him is sure to afford. Meanwhile, we wish his speedy return to health.

In the very short time at my disposal I have attempted to put together a few thoughts on "Some Aspects of Plant Genetics." The scientific study of plant genetics is not of very ancient date, and, in this country, the work done is still of moderate dimensions. There is, therefore, some possibility of taking stock of our achievements and of estimating future progress in this branch of botanical science.

I am not forgetful that this is the section of pure botany, and that matters affecting agriculture and applied botany are dealt with by another section of this Congress. But I myself, in my professional capacity, am somewhat of a hybrid between a pure and an applied botanist, an F_1 hybrid, if one might so express it, with applied botany partially dominant. I trust that the partially

* Presidential Address to the Botany Section of the Seventh Indian Science Congress, Nagpur, 1920.

recessive character of pure botany may in this address be a little in evidence, even if tinged and modified by the stronger allelomorph. In this connection I would quote the following words [1] of Professor John M. Coulter at the Baltimore meeting last year of the American Association for the Advancement of Science:

"In the days ahead, the botanist who remains narrow will be stranded. We must recognize in every field of botany an important factor in the solution of problems. A man is expected to think his own field the most important, but if he thinks other fields unimportant, he has blocked his own progress and is bound to move in ever narrowing circles. One of the demands upon us, therefore, is to cultivate the synthetic attitude of mind; to develop about our own specialty a penumbra of the botanical perspective. In other words, botanists must cease to be provincial, they must not be citizens merely of one small group, with no larger contacts, but citizens in the world of science. We must not remain persistently in the narrow valley in which our work lies, but we must get on to the mountain top often enough to realize the perspective.

"The new opportunity demands this; in fact, it was this that created the new opportunity. This means that we are to see to it that botany is recognized as the greatest field for universal service. Medicine holds that opinion now in public estimation, simply because it ministers to the unfortunate, but they are in the minority. Botanical research underlies an essential ministry to all. Disarticulation of botany from its practical applications has been most unfortunate and must not be continued. What we have failed to do is to establish the contacts between science and practice, to indicate the possibilities of every advance in knowledge in the way of public service.

"This is very far from meaning that every investigation should have an obvious practical application. Research must be absolutely free, stimulated only by its interest in advancing knowledge, but the importance of fundamental knowledge in solving practical problems should be emphasized at every opportunity."

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[1] *Science*, April 18, 1919, pp. 364–365.

Do not, I pray you, take these words which I have quoted as a criticism. I pass them on to you as a stimulus to that broad scientific scholarship and healthy co-operation which in these specialist days is all the more necessary. And I would also remind you that while the specialist brings the material, it is the scientist of larger outlook who can from special facts build up those generalizations that give coherence, meaning and power to our knowledge. Different men have different talents, one may be an ideal investigator and another an ideal interpreter, but the investigator will be none the worse of a knowledge of what is going on in branches other than his own, nay, he will bring his rough material at least a little hewn and squared for the final building.

Plant genetics (or the study of heredity in plants) is one of those subjects in which fundamental scientific truths discovered or in process of discovery by pure scientific workers have been of immediate value in their practical application. It is, however, the case that the progress of research in genetics is in advance of the degree of use to which the truths discovered can be put. There is no fear of genetics degenerating into a mere mechanical art, if such there be. Again, it must be remembered that much of the earlier material for the study of genetics came from the records and experiments (crude though both were) of men who were not scientists, but practical breeders. Genetics, therefore, is one of those branches of science where, if anywhere, there should exist the most understanding and cordial co-operation between the pure and the applied scientific workers.

Let us look for a little at the historical aspect of plant genetics. I do not propose to repeat in detail facts which are so well put in the various histories of botany now available. The citation of a few names will serve to recall to you the general trend of work in the past. Previous to or contemporaneous with Mendel (whose main work, you recollect, was published in the middle of the nineteenth century) we have among practical breeders Van Mons of Louvain, who originated many varieties of pears; Knight of Britain, also a horticulturist; Shirreff, a Lothian farmer and originator of valuable varieties of cereal crops; Cooper, an American and a discoverer

of the benefit of selection as against mere "change of seed." Among pure scientists I may cite the names of the hybridists Kolreuter and Gärtner, assiduous experimenters; Charles Darwin, than whom no more painstaking or successful compiler of information ever existed; and lastly Mendel himself. With the re-discovery of Mendel's work and the fact of its standing the test of repeated experiments began the new era in the study of heredity. The term Genetics, happily devised by Bateson, is now applied to this new branch of biological science. Bateson, Punnett, Biffen, the lamented Darbishire and others have built up this branch of the science in Britain. America provides a legion of enthusiastic workers whose productions bid fair to outstrip those of any other nation. On the Continent there are many pioneer and famous workers whose names are household words wherever biology is studied. A glance at the membership of the International Conference of Genetics will refresh your memory. In India such work as has been done in plant genetics has been mainly (but not entirely) due to the botanists of the Department of Agriculture. There is no reason, however, why such work should be confined to them, and every reason against it. On account of their being members of an agricultural department their work on genetics is naturally confined to plants of economic importance. There are thousands of other plants presenting new and fascinating genetic problems that would amply repay the research of those who are not bound to deal only with agricultural plants. And, again, there is no reason why botanists of the department of agriculture should not welcome co-operation in the study of agricultural plants from those not in the department. Professor Fyson[1] some time ago published a useful paper on heredity on cotton, and I propose in a later part of this paper to put before you some problems in which I believe all can lend a hand. From the side of practical usefulness, or from the side of the search for fundamental truth, there is a large field in India for genetical investigation. We have the added advantage of being able to grow in the open air many plants that can live only in glasshouses in Britain and most parts

[1] Fyson, P. F. *Memoirs of the Dept. of Agriculture in India, Botanical Series*, Vol. II, No. 6.

of America and the Continent, and therefore a great incentive to the study of such plants.

An additional reason for the study of plant heredity experimentally by non-agricultural botanists is the fact that the subject of heredity in plants and animals now figures in the science syllabus of most of the Indian Universities. Actual material is necessary for the instruction of the student and the enlightenment of the teacher.

This brings me to the second aspect of plant genetics with which I desire to deal, namely, its educational aspect. At this stage in the world's progress and in the progress of India, it is surely unnecessary for me to insist on the desirability of training in science as an essential part of all education. Yet old prejudices die slowly. The eloquent words of Huxley [1] put the matter concisely, and are worth requoting: they serve once again to bring before us the main end that the study of plant genetics and of other sciences ought to serve in education.

"Yet it is a very plain and elementary truth that the life, the fortune, and the happiness of every one of us, and more or less of those who are connected with us, do depend upon our knowing something of the rules of a game infinitely more difficult and complicated than chess. It is a game which has been played for untold ages, every man and woman of us being one of the two players in a game of his or her own. The chessboard is the world, the pieces are the phenomena of the universe, the rules of the game are what we call the laws of Nature. The player on the other side is hidden from us. We know that his play is always fair, just and patient. But also we know, to our cost, that he never overlooks a mistake, or makes the smallest allowance for ignorance. To the man who plays well, the highest stakes are paid, with that sort of overflowing generosity with which the strong shows delight in strength. And one who plays ill is checkmated—without haste, but without remorse.

"My metaphor will remind some of you of the famous picture in which Retzsch has depicted Satan playing at chess with man

[1] Huxley, T. H. *Lay Sermons, Essays and Reviews*, 1870, pp. 36-37.

for his soul. Substitute for the mocking fiend in that picture a calm, strong angel who is playing for love, as we say, and would rather lose than win—and I should accept it as an image of human life.

"Well, what I mean by education is learning the rules of this mighty game. In other words, education is the instruction of the intellect in the laws of Nature, under which name I include not merely things and forces, but men and their ways; and the fashioning of the affections and the will into an earnest and loving desire to move in harmony with those laws. For me, education means neither more nor less than this. Anything which professes to call itself education must be tried by this standard, and if it fails to stand the test, I will not call it education, whatever may be the force of authority or of numbers upon the other side."

It behoves us botanists, as enthusiastic believers in this doctrine, to push it at every opportunity. In our capacity as teachers, members of the governing body of a college or a university, or merely as private citizens we should do our best at every turn to get this idea worked into the fabric of Indian education which still suffers from the very faults against which Huxley inveighed. We desire above all things firmly to establish in the human mind that belief in causation, the inevitable chain of events, that makes a man free of superstition, able to weigh evidence and arguments, and amenable to reason. Such characters make for good citizenship and for personal and business morality. I would not weary you with quotations, but I would commend to your attention the very full treatment of this matter given by Karl Pearson, himself a geneticist, in the first chapter of his "Grammar of Science." The study of genetics is of value also as an introduction to sociology. Eugenics is the genetics of the human race. In genetics of plant or animal, problems of heredity and environment meet the student at every turn and the methods of attacking these are of use in his further work in sociology and eugenics. We desire, therefore, for these reasons to broaden the circle of those who appreciate genetic laws, and this can be done only if genetics forms a part of education.

I am not prepared to give a dogmatic opinion as to the stage at which genetics should be introduced into education, but I would observe that a teacher, himself trained in genetics, will be able in the course of an ordinary school Nature-study course to lead his pupils to observe some of the salient facts of heredity and environment. Caution and tact are, of course, essential. It will not do at all if we find the said teacher expounding Mendelian ratios to his bewildered class. But there are many facts of variation, a great many of adaptation, and a certain number of inheritance that can be quite well employed.

In our college and university courses the matter should be dealt with as fully as possible, and that "possible" can be very full indeed. This can only be, however, if the college or university is provided with some place where plants can be multiplied, reared and observed in successive generations. A *sine qua non* of a modern botanical installation ought to be a breeding garden including a plant house for plants that need protection, and if no other space is available, some part of the existing botanical garden should be given up to this purpose. The teacher must, of course, be able to grow his plants successfully. Although he may not be much of a gardener to begin with, the failures of one season will help him in the next, and it will not be long before he can grow anything with roots, and teach his students to do the same.

As one who has had a little experience in the teaching of plant genetics as part of a college course, I may be permitted to indicate one or two important points and some difficulties in this teaching.

For the study of variation we are surrounded by endless material. The leaves of the fig, mulberry and other trees give us examples of extreme leaf variation in the same tree. Any field of an annual crop will provide material for the study of variation between individual plants in height, colour, productiveness, etc. The students should weigh or measure a series of natural objects and the total results of the work of the class can be put together and plotted to show the frequency curve. Seed of extreme and mediocre samples from self-fertilized plants can be saved for the study of the next generation. Without some such practical introduction I have

found it difficult to get men to understand the curve of frequency and, as its explanation must necessarily come very early in the whole subject of genetics, inability to grasp its significance means disheartenment and cessation of interest and progress. I am inclined to think that the more mathematical part of plant genetics should be left to a little later in the programme. If too much of this is given at the start the student is both frightened and bored. He asked for plant genetics, and behold mathematics. After some of the more interesting work we can again recur to the mathematical aspect and the student will be more able and willing to deal with it.

A keen look-out should be kept for mutants, so that students may see actual examples of these. Unless one knows the pedigree of a given culture, one cannot, of course, say that a given aberrant plant is a mutant, but aberrant plants found in otherwise homogeneous cultures where vicinism is unlikely may be called mutants unless their posterity shows otherwise. Ornamental garden annuals are the last material to be used for this study as they are the result of long processes that probably included crossing and hence an aberrant plant may be merely the result of a heterozygote splitting.

The study of natural self-pollination and cross-pollination can be carried out with ease on any large-flowered plant. The Malvaceæ present an admirable series for this purpose. I would solicit your attention to the admirable teaching material that may be extracted from certain memoirs of the agricultural department dealing with this subject.

Plants of the Malvaceæ and plants of the Leguminosæ can be used for hybridization practice and to illustrate the law of Mendel. It is, of course, necessary to be sure that one is dealing with pure homozygous parents, and this can only be ascertained if one breeds the plants for at least a generation from self-fertilized seed.

Maize offers many interesting and easily demonstrable points. There is also a large literature about the genetics of maize. In maize, crosses between plants with different endosperm show the xenia effect in the cob of the female parent and the selfed F_1 plant will show the Mendelian ratio in its cob. A cob with many types of seed on it, not an uncommon phenomenon, offers an excellent

starting point for the isolation of its constituent races. The only difficulty about maize is its tendency to degenerate when repeatedly self-fertilized. Its great advantage, in addition to those mentioned, is the great number of generations that can be crammed into one year. In the dry season the plants need a very heavy manuring to prevent premature flowering and perhaps the failure to form female inflorescences.

For the expounding in the lecture room of Mendel's law and its effects various devices have been invented. Here is one that I have been instrumental in introducing. The apparatus is two packs of ordinary playing cards. These are familiar objects to the students, and their appearance on the lecture table of a staid professor excites a certain amount of amusement and the necessary interest. The black and red are supposed to be the allelomorphic pair, black being dominant to red. The union of a black and red gamete is easily shown and the character of the F_1 hybrid is shown by a black card hiding a red one. The gametes of the F_1 hybrid are represented by a pack each. One pack being the female and the other the male gametes. The essential part of the demonstration is the very thorough shuffling of each pack. I usually get three students in succession to shuffle each pack. In fact I let the students carry through the whole thing so as to avoid any appearance of any other agency than chance. One card is then taken from each pack and each pair is classed under one of four heads Black-Black, Red-Red, Black-Red, Red-Black. In theory there ought to be 13 under each head. This fairly often comes out. If it does not, one has an excellent opportunity for explaining the nature of chance, and showing how with a larger number there is a greater likelihood of gaining the theoretical ratio. Coloured counters or beads may be similarly used. The mating of plants differing in two pairs of allelomorphs can be worked out by using beads differing in colour and in shape, tied together in the appropriate pairs. These may then be mixed in a bag and brought out in a manner similar to that used for dealing with one pair of allelomorphs.

An interesting method of explaining Mendelian phenomena as distinct from demonstrating them is that described by Professor

Love Holmes Miller[1] of the State Normal School, Los Angeles, California. He reasons thus:

"Practically every high school graduate has had at least a year of algebra and has learned by rote the square of $a + b$. Whether or not he remembers that $a^2 + 2ab + b^2$ represents all the possible combinations of the two factors, he is in a position to be reminded of that fact and to take the first short step into the unfamiliar. If a and b represent the two types of gametes produced by the heterozygous parents F_1, then $a^2 + 2ab + b^2$ represents all the possible progeny in the F_2 generation. Factors of second power represent pure strains, because the determiner is the same from both parents. Conversely, factors of the first power represent heterozygotes or the union of unlike determiners.

"The greatest service of the method appears when the two sets of allelomorphs are combined. The student has learned to multiply $a^2 + 2ab + b^2$ by the expression $x^2 + 2xy + y^2$. He will perform the operation as one familiar to him and he can readily be taught to recognize the four pure strains $a^2 x^2$, $a^2 y^2$, $b^2 x^2$, $b^2 y^2$. Suppose a and y represent the dominant characters and b and x the recessives, emphasizing the fact that the dominant is effective whether appearing as a first or as the second power. Suppose a represent tallness and y represent red flower in a plant. Gathering the results of the multiplication according to visible attributes we have four columns representing the Mendelian ratio 9 : 3 : 3 : 1.

Tall red	Tall white	Dwarf red	Dwarf white
$2\ a^2xy$	a^2x^2	b^2y^2	b^2x^2
$4\ abxy$	$2\ abx^2$	$2\ b^2xy$	
$2\ aby^2$			
a^2y^2			
9	3	3	1

This is only one of many devices all alike fundamentally, but it has the great value of utilizing a familiar process. Many times I have seen it clear up a badly fogged situation. It is worth trying on the discouraged pupil at any rate."

[1] *Science*, February 7, 1919, pp. 148-149.

I believe it to be an excellent method to have large scale pictorial records of the progeny of a selection or a cross through several generations and hang them on the wall of the genetics laboratory.

Practical work in a genetics course must obviously run for two years and must involve the study of variation, the isolation of types, the selection of plants and the study of their progeny, the technique of hybridization, the study of the progeny of hybrids, and the methods of recording breeding work.

Much observation of a completely new type can be done on floral mechanism and floral physiology. The observation of the time of opening of flowers, timeof anthesis, time of ripening of the stigma, fertility and longevity of pollen, period between pollination and signs of fertilization, etc., afford admirable educational discipline. The observation of the opening times of some flowers may involve getting up once or twice during the night, and this should not be shirked by advanced students.

For students who intend to present an M.Sc. thesis I can imagine no more fertile subject than plant genetics, provided the material is carefully chosen and the work well guided.

We are now fortunately much better off for text-books than we were a little while ago. There is a new edition of Punnett's "Mendelism," and Darbishire's book on the same subject is of great use. From America we have the useful "Plant Genetics" of Coulter and Coulter, also Babcock and Clausen's "Genetics in Relation to Agriculture," and Coulters' "Fundamentals of Plant Breeding." There are at least two journals devoted to its more severely scientific side, and we have the invaluable "Journal of Heredity," the organ of the American Genetic Association, which is a priceless possession to the teacher of genetics. I notice that Babcock and Clausen have made free use of material that has appeared in its pages.

I think I have said enough to demonstrate the value of plant genetics as an instrument of education and to show how this instrument may be wielded. The study of plant genetics lets the student see the plant in action and it allows him to play with life in a manner afforded by no other branch of the science of botany.

Plant genetics is a subject, however, that can be easily spoiled by putting the theories first and the evidence second, as is too often the practice. I would quote to you in this connection the following words of one whose assistant I had the honour to be—Dr. Frederick Keeble[1]:

"The first duty of a teacher (is) so to select and present common facts that the essential generalizations which cohere them into a scientific system, either suggest themselves to the mind or, at all events, appear natural and convincing when the teacher is compelled by the defectiveness of his method or the indifference of his students to expound."

In concluding our study of this aspect of the question let me put before you as a goal that which McCurdy[2] informs us was the aim of Leonardo da Vinci, that great, free spirit of the 15th Century: "It was the cramping fetter of mediæval tradition upon thought which Leonardo tried to unloose. It was his aim to extend the limits of man's knowledge of himself, of his structure, of his environments, of all the forms of life around him, of the manner of the building up of the earth and the sea and the firmament of the heavens. To this end he toiled at the patient exposition of natural things, steadfastly, and in proud confidence or purpose."

Plant genetics, in its utilitarian aspect, means the production of new and better plants, and the keeping of these up to standard. This aspect of the work has been very fully reviewed by Sir Daniel Morris in his address to the Botany Section of the British Association for the Advancement of Science last year. There are one or two additional points, however, that I should like to put before you, both as regards work done and as regards possibilities for further work.

Bergson,[3] treating of the living body in general, says:

"It is an *individual*, and of no other object, not even of a crystal, can this be said, for a crystal has neither difference of parts nor diversity of functions. No doubt it is hard to decide, even

[1] F. K(eeble) in *Nature*, September, 1919, p. 47.
[2] McCurdy, E. *Leonardo da Vinci's Notebooks*, 1906, p. 10, Introduction.
[3] Bergson, Henri. *Creative Evolution* (translation by Mitchell), 1911, p. 10.

in the organized world, what is individual and what is not. The difficulty is great, even in the animal kingdom; with plants it is almost insurmountable. This difficulty is, moreover, due to profound causes, on which we shall dwell later. We shall see that individuality admits of any number of degrees, and that it is not fully realized anywhere, even in man."

My preceptor, Professor Bayley Balfour, puts the same idea in a formula by stating that the plant is a *colonial organism.* Its various parts are to some extent independent of each other, and isolated parts can reproduce those missing. It is not to be wondered at, therefore, that we find these parts varying among themselves, nor that such variations are at times inherited. I refer, as you perceive, to *bud variations.* It is a well-known fact that a bud on a tree may give a branch the leaves, flowers and fruit of which are different from those of the rest of the tree, and that these peculiarities may be transmitted to the next generation either vegetatively or sexually. Varieties of sugarcane have been observed to arise by this method, and changes in the fruit of trees have been observed to follow such bud mutations. It is particularly with reference to the study of bud variation in Indian fruit trees that I think a great deal of work can be done. These variations may be useful or harmful from the practical point of view. Care is needed in weeding out the harmful and preserving the useful variations. Let me cite to you, as an example of the kind of work I mean, what has been done on the Washington Navel Orange, a variety which is the mainstay of the Californian citrus trade.

The following facts are culled from articles that have appeared from time to time by fruit experts in the pages of the "Journal of Heredity."[1]

The navel orange, as its name implies, is one that has a peculiar umbilical protuberance at the stigmatic end. The Washington navel orange originated at Bahia, Brazil, as a bud variation of the

[1] *Journal of Heredity:* Vol. VI, No. 10, "Washington Navel Orange," by A. D. Shamel; Vol. VII, No. 2, "Bud Variation," by A. D. Shamel; Vol. VII, No. 10, "Forgotten Bud Variations," by L. B. Scott; Vol. VII, No. 11, "Co-operation in Production of California Grape Fruit, *anon.*

Portuguese variety of orange, *laranja selecta*, or the select orange. This variety, says Shamel, whom I quote, was undoubtedly introduced into Brazil very soon after the colonization of that country. According to V. A. Argollo Ferrao, one of the agricultural officials of the country, the navel orange appeared as a bud variation of the *selecta* variety and was discovered and propagated by a Portuguese gardener at Bahia about 1822. This account of its origin has been confirmed by all other available information.

Here, then, we have an authentic case of a valuable fruit arising by bud variation. The orange is seedless, has this peculiar navel, and is of excellent quality and appearance. The Bahian navel orange as above described was introduced into the United States through the efforts of William Saunders, then Horticulturist and Landscape Gardener for that division of the Patent Office corresponding to the present United States Department of Agriculture. The first consignment of trees died on the way, but the second got through, though in poor condition. Buds from these were propagated on seedlings of the same variety grown from seed that Saunders had acquired separately. Trees were ready for distribution in 1873 and a Mrs. Tibbetts of Riverside, California, got two of these. From these two trees has sprung the Californian industry, for the budwood from new plantations was taken from them. In 1915, there were about 100,000 acres under this variety in the State. So far so good. We have here an excellent variety, originating as a bud variation, propagated by vegetative methods, the whole population of these trees in California forming two "clones." A "clone" is a race propagated vegetatively from one source. One would have thought that the growers' troubles were ended.

Very far was this from the case. It soon began to appear that within the variety now named Washington Navel by the growers there were various types of tree, distinguished by habits of growth, density of foliage and other characteristics. In addition, there appeared to be a steady and unaccountable deterioration in the trees of new plantations and in the fruit of these. Careful investigation by Shamel revealed the fact that there were eleven common types of the navel orange in California in 1909, and of

these the most undesirable from the standpoint of fruit production were those showing the greatest vigour of growth. These undesirable trees produced in great quantity thick succulent branches, the so-called suckers, from near their base, and these branches had been freely used, nay, actually selected as the source of budwood for the preparation of new stock. The reason is not far to seek. As every gardener knows, one wants a big bud, from a round stem with an easily separable bark, and these requirements were met by the sucker growth. The evil effect can be easily imagined, namely, the new plantations were nearly filled with these "drone" trees, and Shamel records cases of plantations in which as many as 70 per cent. of the trees were of this bad type.

Now whence had these eleven types arisen, including the evil drone types? Obviously from further bud variation, for the orange is seedless and is never propagated except by buds.

What was the remedy? Obviously, to select the best of these variations and take budwood from that only. How was this best variation to be selected? On the same basis that one selects a good cow, by *performance*. Performance records were therefore kept for several years of the fruit production and quality of individual trees and blocks of trees, and on this basis trees for fruit propagation were selected. A drastic change was also introduced by using, for budwood, not the fat juicy sucker, but the wiry twigs just at the back of the fruit growth of the current year. This may seem bad horticulture, but it has in practice proved brilliantly successful, and Shamel states that a certain co-operator budded more than 13,000 orange seedlings with such budwood in 1914 and only two of these failed to grow.

The Californian growers of grape fruit (otherwise the pomelo) have gone a step further. In the grape fruit the same difficulty arose and the same remedies have been found successful. The Grape Fruit Club, one of the growers' organizations, has decided to eliminate from their groves all varieties except the Marsh (the most useful variety) and further to eliminate all Marsh except one type. By this means they will standardize the product of all the members of the club with great advantage to both producer and consumer.

Similar problems present themselves in the citrus groves of India. The gardener, and the plant breeder also, are sometimes apt to think that within a clone purity must reign and variation be abolished. The experience of those who investigated the Washington navel orange was, as we have seen, quite otherwise. A walk through any orange grove on this side of India will show you that here too bud variation does occur, and I commend its study to future investigators. Tree differs from tree, branch from branch and even, occasionally, fruit from fruit on the same branch. The matter is one of common observation among the illiterate cultivators themselves. There is here a clear field for an inviting and useful research, and we have a good lead from the American work as to how to deal with the problem.

Another phenomenon on which as yet little work has been done in India is that of the seedlessness of fruits. Seedless fruits are in many cases extremely desirable. The guava, for example, is spoiled by the multitude of extremely hard seeds that occupy such a large part of its pulp. There is a belief current among guava cultivators in Poona that repeated vegetative propagation of the guava tree will reduce the number of seeds. This belief was experimentally tested by my assistant, Mr. L. B. Kulkarni, L. Ag., who layered the guava repeatedly and tested the guava fruits got from each successive layer generation for number of seeds. This experiment was carried to the third layer generation without effect on the seed number.

Some years ago I advertised in several newspapers for seedless guava trees, and received many so-called seedless trees, all of which produced fruits bearing seeds. Races of guava trees do, however, vary immensely in the number of seeds produced, and a Sind variety, now recommended and propagated in the Ganeshkhind, Botanical Garden, Poona, has a very small number indeed. It may be possible to get at this seedlessness by selection of trees or buds within this variety.

Another possible way of attacking the problem is by a cross between different species of the genus Psidium to which the cultivated guava belongs. A fruit-producing but seedless guava may in this

way be produced. This method has been tried by my assistants, but as yet without success.

Similar improvement is desirable in the custard apple (*Anona squamosa*), also an excellent fruit spoiled by large and numerous seeds.

The seedlessness of the cultivated banana (*Musa sapientum*) is a subject of interest genetically, especially considering the free seeding character of the wild species (*Musa superba*). Apparently fully developed seeds do occur occasionally in edible bananas, more especially in certain varieties. Fawcett [1] mentions that seeds were secured when the pollen of the red banana was dusted on the stigma of the ordinary banana at Hope Gardens, Jamaica, but that the hurricane of 1903 levelled the plantations before the seeds were ripe. Apparently there has been no further Jamaican experiment. Experiments made by myself and my assistants in Poona in 1916 showed that seeds were produced in small quantity in fruits of *Musa sapientum* when pollinated by pollen of *Musa superba*. The viability of these seeds was never tested as they were lost, and war work afterwards prevented the repetition of the experiment. Seeds occurring in the Mhaskel variety have been dissected by me and found to be mere hollow shells. It is an established fact that the fruit of *Musa sapientum* develops without the stimulus of pollen.

All this does not give us much light, however, on the cause of banana seedlessness. Tischler [2] found that three races of banana investigated by him had different chromosome numbers, namely, 8, 16, and 24. He found also that with increase in chromosome number appeared a derangement in pollen development. Abnormal tetrads and nuclei were thus formed, but some of these could give normal pollen tubes. The numbers of chromosomes given above were the reduced numbers. In somatic cells pro-chromosomes, by which name he called centres sharply defined by hæmatoxylin, scarcely ever indicated a diploid nucleus, but there was a tendency for two or more to fuse.

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[1] Fawcett, W. *The Banana*, 1913, p. 18.

[2] Tischler, G. *Untersuchung uber der Entwicklung der Bananen Pollens* I. Heidelberg, 1912.

I have made a considerable number of careful sections of the ovary of *Musa sapientum* at different stages of growth of the flower, but have failed to observe an embryosac. I was unable to complete this study owing to the war and to leave, but the whole indications were of a feebly developed or missing embryosac.

Beccari,[1] writing of the origin of the cultivated banana, says:

"The wild varieties are almost wholly seeds, but what pulp exists is sweet and agreeable. It therefore only requires some agent to inhibit the growth of seeds and promote that of pulp to produce good bananas. Effective causes are sterility produced by hybridization and improvement by asexual reproduction."

Now this airy disposal of difficulties does not at all meet the hard facts of the case. We have already seen that in guava repeated vegetative propagation for three generations does not alter the number of seeds. Second, I fail to see how you are to propagate *Musa superba* vegetatively, for in all the places where I have seen it, it produces no suckers. It may be different with other wild seed-bearing varieties, of course. Next, the question of hybridization. This is possible, of course, but no one has yet produced a seedless *Musa* from two seed-bearing species. This remains to be done. The abnormal nature of the pollen would seem to point to some great disturbance of the germ cells and this might possibly be due to a wide cross. On the other hand it might be only a mutation affecting chromosome number, like *Oenothera lata* from *O. Lamarckiana.*

The matter is, therefore, one on which we have no exact information, and is complicated by the statement of Baker[2] that *Musa Fehi,* which grows widely in Tahiti, is seedless at the lower levels of the forests but bears seeds when found at higher altitudes, say 3,000 to 3,600 feet.

I submit that the problem of seedlessness in fruit is one for the investigation of which much material exists, little work has been done, and great rewards are in readiness.

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[1] Beccari, Odvardo. *Nelle Fineste di Borneo Firenze,* 1902, p. 611.
[2] Baker, J. G. *Annals of Botany,* VII, 204.

The question of the inheritance of sex in plants presents itself to us in our indigenous plants papaya (*Carica papaya*) and Indian hemp (*Cannabis sativa*). Just as in considering the question of seedlessness we very soon got away from the purely utilitarian aspect and found ourselves in the rarefied atmosphere of pure truth, so here also we very soon find that the practical application of the research awaits entirely the disinterested labours of the pure scientist. In the case of the papaya we at present can see no difference between the male, hermaphrodite and female trees until they flower. If some means of distinguishing them at an early date were found, much useless planting and much loss of labour, water and manure would be prevented. Or if a race of papayas could be produced with a very large percentage of female trees, a great boon would be conferred on tropical fruit growers. But both problems still await solution.

Investigation has been done by Higgins [1] and Holt in Hawaii, and by my assistant, Mr. L. B. Kulkarni,[2] L. Ag., in this country. The result of such enquiry up to date is about as follows: The papaya shows trees purely male, trees purely female, and several types of hermaphrodites. Of these hermaphrodites there are at least two clearly defined types, namely, (1) a type which produces occasional fertile flowers on a long peduncle bearing for the most part male flowers; (2) a type bearing fertile flowers of larger size on a short peduncle that may have male flowers upon it. The fruit of the second type is often elongated, and on account of the short peduncle is borne fairly near the stem. All these types may occur from one set of seeds. Moreover, in the lifetime of one tree there may be a change of sex. This may occur without any special apparent exciting cause or it may be induced by beheading the tree. Kulkarni observed one case of a tree that had completed the whole cycle of sex and come back to its original condition in its own lifetime.

Both in Hawaii and India experiments have been made in pollinating the ovary of a pure female tree with pollen from a

[1] Higgins, J. E. "Growing Melons on Trees." *Journal of Heredity*, VII, 5.

[2] Kulkarni, L. B. *Ann. Report, Ganeshkhind Botanical Garden*, 1913-14, and succeeding years.

hermaphrodite tree, with the object of getting a race with a large percentage of female trees. That one does get an increasing percentage is shown by results, but the limits of such breeding and the scientific interpretation are still unknown.

Again, there is something rather mysterious about the formation of the papaya fruit. One often sees a lone tree at a railway station or some out-of-the-way place, with apparently no male near it, and yet bearing fruit. In Ganeshkhind Garden we bagged a certain number of flowers to see if fruit set without pollination and it was found that it did. The seeds within these fruits were not viable.

There appears to be here some hint of parthenocarpy, and again much material ready to hand for a most fundamental research.

The ratio of the different types of tree from seed of known origin is also a matter requiring investigation.

To turn to the second example of bisexual plants, namely, *Cannabis sativa*. A most interesting series of experiments on the determination of sex in this plant was carried out by Ciesielski [1] in Lemburg between 1871 and 1878. According to his results, fresh pollen produces males and stale pollen produces females. I do not remember to have seen any recent repetition of this work to enable me to judge of its truth under modern conditions of rigid scientific control.

Changes of sex in hemp have been repeatedly observed, both without apparent external cause and with such.[2] Removal of the flowers does alter the sex of hemp, and while only a few male plants produced pistils, they constituted 14 to 21 per cent. of the total number of males reproducing flowers after the operation. It is quite probable that if the proper stimulus were used, says Pritchard, pistil formation could be induced in all males. He also states that the females were very responsive to the stimulating effect of flower removal. In fact, in the second year's experiments every female operated upon produced an abundance of stamens.

[1] Wester, P. J. "The Determination of Sex." *Journal of Heredity*, V, 5.
[2] Pritchard, F. J. "Change of Sex in Hemp." *Journal of Heredity*, VII, 7.

Schaffner [1] records a case of complete reversal of sex from femaleness to maleness in hemp with no special treatment.

This plant, therefore, deserves further study, and as it grows easily here, we should be the people to carry on that study.

One point comes out clearly in the discussion of the above facts regarding papaya and hemp, and that is that sex does not appear to be, in these cases, entirely a matter of zygotic constitution. It would appear that both are potential hermaphrodites as believed by Darwin and Strasburger, and again as pointed out by Pritchard.

Again, very little, if anything, has been done to test grape seedlings in this country, and yet when one considers the new varieties of value that have been thus originated in other countries one feels that here too is a promising and obvious field for work.

Among ornamental plants there also exists an untouched and attractive region for research and profit. We have many wild plants that would probably repay domestication and breeding. When one considers what has been done in a few generations with phlox and petunia one feels that many of our wild plants may hold similar possibilities. And when one sees to what miserable specimens uncared-for florist's plants can degenerate one looks through the other end of the telescope, as it were.

The production of horticultural seed in this country is an industry offering, I believe, great scope for the practical scientist or the scientific practitioner.

I have dwelt on the horticultural aspect of utilitarian plant genetics because it is one that is too often neglected, and yet horticultural products are a great part of the country's wealth and its gardens are æsthetic riches.

A word or two must be said regarding the relation of plant genetics to other branches of botanical activity. At present cytology is most intimately connected with plant genetics. The investigation of chromosome numbers, distribution, and arrangement

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[1] Schaffner, J. H. "Complete Reversal of Sex in Hemp," *Science*, September 26, 1919, p. 311.

forms no small part of the knowledge which the geneticist must have in order to elucidate many points of his problems. The recent work by Arber and Beer, recently discussed and criticized by McLean,[1] on multinucleosis in the developing soma cell of the higher plants opens up an entirely new field of speculation. The value of the chromosomes in heredity and the meaning of nuclear fusion, whether of gametes or of somatic nuclei, are points which at one time appeared to be as settled as anything in science. They have now again come under the fire of rigid investigation, and we shall in all probability soon be able to chronicle further advances in our ideas regarding both these important matters.

In relation to taxonomy, genetics has a large part to play, a part on which genetics has as yet hardly entered. Genetics, we may truthfully say, is the experimental form of the study of evolution. In taxonomy our aim is to relate in groups such plants as are genetically connected. Up to date, on account of the mass of new material to be handled, taxonomists have based their reasoning chiefly on observation of individual generations either in a single habitat, or too often entirely apart from the habitat. The only real test of a variety is to grow it, and see if its characters are retained. It is necessary to test it also in varied environment and to see how far its new characters are inherent and how far due to environmental influence. It may seem at first sight as if this were a thing impossible, but it is not a thing which can or should be done all at once. There is, in addition, a fertile field for hybridizing existing species and varieties, when the origin of others may be elucidated.

To return again to genetics as the experimental form of the study of evolution. As such it must always take a central position in the study of life, for as Bergson has said, life is essentially a "becoming." Man has always been curious about the manner in which new forms arose, and in genetics we may get a long way toward knowledge of this point. You will observe I do not say why new forms arose. That is more a question of pure philosophy and

[1] McLean, R. C. "Sex and Soma." (Paper read before Linn. Soc., Lond., November 20, 1919.)

for its answer I know no better master than Henri Bergson, whose reasoned theory of the "vital impulse" is at once inspiring and encouraging.

We must clearly recognize the limits set upon our experiments and our generalizations by the nature of plants. On account of their food habits, their immobility and lack of consciousness, they offer themselves as easy material to even the unpractised experimenter. The possibility of keeping relatively large numbers under culture and observation enables us to gain facts regarding posterities and to keep a look-out for mutants which are the more likely to appear, the greater the number of plants grown. The large number of nearly related but diverse forms enables us to study inheritance in crosses between nearly similar varieties.

Wherein, then, is this material imperfect ? Perfect it certainly is for itself, but we should beware of drawing conclusions regarding characters which have not been investigated, characters more developed in animals, or characters which appear to be more part of the life of the individual and less part of the material in which that life clothes itself. For as Darbishire[1], following Bergson, states :

"Let us now consider concisely the four main conclusions to which a consideration of M. Bergson's philosophy has led us :—

1. Time is the essential factor concerned in the fixation of the characters of organisms.
2. Life is perpetually creating the absolutely new; more is got out in the effect than is put in in the cause.
3. The performances of living things cannot be predicted mathematically.
4. The organism consists of an essentially vital part and of non-living constituent parts."

He goes on to say :

"His (Bergson's) conclusions with regard to life are untrue of Mendelian characters. This may mean either (1) that M. Bergson's conclusions are ill-founded, or (2) that the Mendelian characters

[1] Darbishire, A. D. "An Introduction to a Biology," 1917, p. 98.

are dead or, at any rate, appertain to the least vital parts of the organism. I believe the latter alternative to be nearer the truth. If it is nearer the truth, we have, I think, a clue which will enable us to relegate the Mendelian characters to their true position among the characters of living things; and a suggestion which may enable us to determine without experimentation which characters are likely to behave in a Mendelian way in heredity and which are not. And it would seem, in general, that Mendelian characters are to be found amongst the contents of the retort and are not exhibited by the retort itself."

Again, the study of plant genetics supplies us with practically no data regarding the inheritance of instinct or intelligence. There are certain habitual actions, however, almost resembling instincts, *e.g.*, certain kinds of response to stimuli, whose inheritance in crosses might lead to some new knowledge. An interesting case would be the crossing of a right-handed with a left-handed climber, if such could be made.

Plant genetics, like other studies of heredity, has had two main tendencies, the biometric and the Mendelian. The former aims at the mathematical interpretation of the facts of mass inheritance, the latter at the scientific explanation of individual inheritance. The latter demands the intense study of single lines of inheritance, single plants, single characters. Of this nature is the work of Mendel and of this nature is the work of De Vries on *Oenothera*. It is a method that is essential in future work on the study of heredity in plants. Its intensity is increasing, for whereas in the time of Mendel it was sufficient to follow a single gross character, we now attempt to follow a single chromosome or a single chromomere. We here approach very near to the actuality of Clerk Maxwell's demon, who was supposed to be able to make selection between slowly and quickly moving molecules and thus alter the heat of two parts of a closed system.

This brings us to the question, "What do we actually know, and what can we actually do, in plant genetics?" We may truthfully say that the more we know the more complex does the whole situation become. Judging from recent researches some ideas

that have been dogmatically expressed by certain earlier writers are likely to require considerable revision. A state of uncertainty is likely to supervene on the first apparent state of stability.

But what do we know ?

The facts of variation in external form we can observe, measure and record. The causes of non-adaptive variation we do not know. I defy any botanist living to account for the variation in the lobing of the leaves of a single fig tree.

Concerning the distribution of fluctuating variation we know a good deal and can mathematically express it. The theory of its distribution at present seems to fit the facts. But there arises a difficulty in distinguishing fluctuating variation due to slight changes in environment from variation due to cumulative factors, especially where these mean small changes in quantitative characters. The doctrine of cumulative factors is, of course, still a hypothesis, but it is a matter of fundamental importance and deserves careful experimental study.

Mutations are repeatedly observed in pure cultures. In some cases gross changes in number or form of chromosomes have been observed. In a few cases mutations have been produced by altering the external conditions of the plant or the organ. In no case are the mutations adaptive. It appears proved that mutations are due to alterations in the germ plasm, but that the germ plasm can be got at appears also true. Recent work by Rawson[1] in South Africa shows that by selective screening a new form of *Papaver Rhoeas* has been secured and fixed. If this can be done by a mere variation of light on the externals of the plant, where is the theory of the sanctity of the germ plasm ?

The rôle of the chromosomes as carriers of the plant characters is a matter of some debate, especially in relation to sex. For the sex of plants, as we have seen, can be altered by artificial means altogether apart from the germinal character of the plant. The fact, however, that the male gamete is practically all nucleus and that male characters do appear in the hybrid is a strong argument

[1] Rawson, H. E. "Plant Sports Produced at Will." (Paper read before Linn. Soc., Lond., November 6, 1919.)

for the chromosome hypothesis. The arrangement of characters linearly on the chromosome is still hypothesis on the basis of certain experiments on *Drosophila*.

When we come to hybridization we have an enormous mass of facts capable of varying interpretations. Of Mendel's original theory we can say that as far as the cases dealt with in his experiments go it is true. But, after all, the truth of a theory is not its main virtue. As Duclaux [1] remarked :

"Le propre d'une théorie n'est pas d'être philosophique et séduisante : elle n'a même pas besoin d'être vraie au sens absolu du mot. Il lui suffit d'être feconde."

(The characteristic of a theory is not to be philosophical and seductive : it need not even be true in the absolute sense of the term. It is enough if it is fecund.)

Judged by this standard, Mendel's theory has been amazingly fecund. Hence the progress in twenty years, four of them occupied in a devastating war, is more than in the two hundred years previously, a marvellous phenomenon even when we allow for the improvement in apparatus.

Definite numerical ratios are obtained in many cases but not in all. Where such ratios are obtained, Mendel's law or some modification of it appears to apply. I have mentioned "some modification" and, indeed, there have been so much modifications and so many additional hypotheses (the presence-absence hypothesis inhibiting factors, complementary factors, cumulative factors, linkage, crossing over) that one begins to feel a little uneasy and suspicious of a theory that needs so much adjustment. This suspicion is only to be dealt with by more and more experiment. Things may be, however, simpler than they look. The act may be simple, but we may, as Bergson [2] suggests, be able to view it only as a patchwork. This ought in no degree to retard either our experimenting or our theorizing. It ought, indeed, to incite us to get a viewpoint ever higher and higher above the broadening area of facts.

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[1] Duclaux. *Traité de microbiologie*, Vol. I.

[2] Bergson, H. *Creative Evolution* (translation by Mitchell), 1911, pp. 95–97.

We must, therefore, retain our rôle of keen-eyed watchers ready to pounce on any indication given by Nature in her own silent workings, and we must also perpetually ply her with questions in the shape of all manner of experiment. Our ignorance is great but so also is our hope.

SOME ASPECTS OF COTTON IMPROVEMENT IN INDIA.

BY

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Extract from para 4 of the Indian Cotton Committee's Report—Possibility of Indian cotton replacing American for Lancashire purposes :—

*   *   *   *

"These cottons (of a staple up to $1\frac{1}{16}$th) will only be capable of spinning up to 34s twist and 44s weft in the Lancashire mills, if the conditions of those mills continue as at present."

Extract from newspaper criticism on the Indian Cotton Committee's Report, headed "Lancashire Interest" :—

*   *   *   *

"Exception is taken to the statement in the Report that cotton of $1\frac{1}{16}$ in. staple will spin 34s twist and 44s weft in Lancashire mills. It is asserted (by Lancashire) that the staple for these yarns must be $1\frac{1}{8}$ in. Only if the $1\frac{1}{16}$ in. staple were much more reliable than Oldham's experience shows it to be, would it serve. It would have to be absolutely even, and that is too much to expect of any growth."

*   *   *   *   *   *   *   *

How are we to reconcile these two opinions? The first is the considered opinion of the Indian Cotton Committee, which not only contained recognized experts from the cotton spinning industry of Bombay and of Lancashire, but had an opportunity of inspecting any Indian mills it wished to, as well as of taking and sifting evidence of practical spinners throughout India, and the second is the opinion now expressed by the spinners of Lancashire. What are the reasons for this difference of opinion? It may be that the Lancashire operative will not submit to as many stoppages for breaks in the

spinning of the yarn as the Indian operative. But this can hardly be the case, otherwise Indian yarn would be unable to compete with Lancashire yarn, which would necessarily be of much better quality. Is it that the Indian mills are better equipped than those of Lancashire? This again can hardly be the case. Up to the outbreak of war the number of mills in India, which spun the counts mentioned, were very few in number. It is not likely therefore that during the war, when necessity restricted even the renewals of existing mills, these could install machinery adapted for spinning the counts mentioned.

If we are to find an explanation to the difference between the two statements quoted, it seems evident that we must look for some other reason, and the following is suggested as the probable solution of the misunderstanding.

Lancashire is at a great disadvantage in judging cotton, because she is not a cotton producing country. This means that she never sees cotton until it reaches there in the form of pressed bales. It is much more difficult to judge the value of cotton after it has been ginned and pressed than before, and that this is so is shown by the reports received from England on samples of cotton sent from India. Such reports lay special stress on colour, freedom or otherwise of leaf, broken seed, etc. They may or may not state whether the staple is even or not, but usually merely state the length of the staple in a fraction of an inch with an opinion as to the counts which the sample is suitable for spinning up to. Then follows the estimated value of the cotton in pence. This value is always based on the then ruling price of F. G. F. Middling American whereas it would be much more accurate and of much more value if this were given in percentages taking F. G. F. Middling American as 100. To anyone who has made a study of cotton with a view to improving it, such information is valueless. He is quite able to ascertain this information for himself. He can see for himself what the colour is, whether it is "white" or "creamy-white," whether it is bright or dull or stained. He does not want to know whether it contains leaf or not. He can see this for himself before he sends the sample for report, and if it does contain leaf or broken

seed, it is immaterial as far as he is concerned. Usually leaf is a question of the season and method of picking. The report merely gives information which says either you have had a good or a bad season or else that you ought to insist on more careful picking. He is in a much better position than Lancashire to state what is the length of staple, because he sees it in the *kapas* and can therefore state much more definitely what is the variation in its length and whether this is even or uneven. He is in a much better position also to state whether the fibre has a good natural twist or not, because it is almost impossible to test this from a sample of ginned cotton until this has been spun into yarn. The worker in this country does not want an opinion as to what counts a particular sample of cotton *is considered suitable* for spinning up to. He will have his own opinion on this point, which is probably much nearer the mark. What he does want *are actual spinning tests* which will give him information on this point. These are very difficult to obtain, because it is very seldom the case that mills will take the trouble to make them, and if they do take the trouble to make them and find the cotton is suitable for spinning higher counts than they considered possible, they naturally wish to keep this information to themselves, because it means that they pay less for the raw material.

Then, again, Lancashire is used to quite a different class of cotton to that which is indigenous to India. The bulk of the cotton used there is of the American Upland type which is quite a different class. The individual fibre is very much finer and much weaker. It is quite possible, therefore, that Indian cotton of a shorter staple is capable of spinning as high a count as American Upland provided the staple is even and the natural twist of the fibre is good. Some years ago (1907-08) samples of Indian cotton were sent to Liverpool for valuation to the British Cotton Growing Association. After a considerable time, a letter of apology was received from them stating that they were sorry for the delay. They wrote as follows:— "We have approached several brokers in Liverpool and not one of them would take the matter up, as you know Indian cotton is very little used now in this country and consequently there are very few men who understand it."

On a later occasion samples of cotton, grown from selections of the local Indian cotton, were shown by me to an experienced buyer for his opinion on the spinning value. He stated his opinion that these could be used for spinning up to 26s. As great care had been taken to select these for evenness of staple and also for natural twist in the fibre, I asked him to arrange for spinning tests to be made to find what these cottons would spin up to. This he kindly arranged to do, and although the length of the staple was only 7/8" to 1" these spun a useful 40s yarn. A 50s yarn was spun from one sample which was reported to give splendid results. Another selection was found suitable for spinning 44s yarn.

It is quite possible, therefore, that if, and when, Lancashire knows more about Indian cottons, she may wish to qualify her opinion quoted above, somewhat as follows. With the type and class of cotton which I am using at present, I require a staple of–?–inches in length.

If this is so, then it puts a different aspect on the Cotton Committee's considered opinion. Much has been done in recent years to improve Indian cottons and the information as to where such improved cottons are grown and are available can, without difficulty, be ascertained by Indian mills and doubtless they have procured their supplies of raw materials from such sources. I consider, however, that the Cotton Committee have not gone far enough in their statement. They have stated that for 34s twist and 44s weft a staple of 1" to $1\frac{1}{16}$" is required. Is this so? It may be the experience of the mills because they buy on "type," "class" and "style," and to obtain type, class and style the buyer has to mix. Thus, much of the improvement made in Indian cottons is lost in this process of matching samples. Further, the cotton dealer who supplies cotton to the buyer has imitated the buyer in this process of mixing, but without his knowledge of what the mills require; and this has become so great an evil that the buyer is often in despair in making up his types. Another reason why the length of the staple given by the Cotton Committee is so high is that hardly any mills in India are prepared to pay for quality. [Th]e difference in the price of good and bad cotton of the same

kind barely does more than pay for the blow-room and cardroom loss and, as long as this is the case, it does not pay the buyer to supply high grade cotton. It pays much better to mix this with an inferior quality cotton even of the same variety and grade it up. My experience is that the only person who pays for quality is the village dealer and his main object in doing so is to grade up an inferior quality of *kapas* by mixing. The persons who ultimately suffer are the grower and the mill-owner. The grower because a continuance of this process lowers generally the value of the cotton of the tract, and the mill-owner because it limits the fineness of the yarn which he can spin and makes it impossible for him to produce a uniform standard of yarn. The profit goes into the hands of the middlemen.

My reason for writing this is not to proclaim the work which has been done in the past to improve the Indian cotton but to suggest that much greater use might be made of Indian cotton than is the case at present. Very large sums of money are wasted annually, because the capabilities of Indian cotton are not fully appreciated. This tells not only on the prosperity of Indian mills, but also on the prosperity of the grower. Much more careful testing of cotton is necessary in mills and much more detailed reports are required on samples of improved strains submitted for report.

It is not so many years ago that Lancashire discovered that by different treatment American Upland cotton could largely replace Egyptian cotton, but she only discovered this because the necessity for supplementing Egyptian cotton was forced upon her. Is it not possible that in some such way Indian cotton in part can be made to replace American Upland? If so, then Lancashire's difficulty will to some extent be solved. Is, however, the statement quoted at the commencement of this note the right way to set about it?

THE "TAMBERA" DISEASE OF POTATO.*

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In the Poona district, where the potato crop is a more important one than in any other part of Western India, the plants grown during the rainy season (the *kharif* crop) are severely affected by a peculiar disease, which, on account of the reddish colour which the affected fields acquire, has been termed *tambera* by the potato cultivators. The disease only attacks the *kharif* crop to any serious extent, but of this it is by far the most serious enemy, and, in a year where it is specially prevalent, it often means that the crop of potatoes is so small that the quantity of seed used is barely recovered. It prominently attracted our attention in 1917, and it has been under examination ever since.

The disease attacks the plants in the following manner. At any stage of the plant's growth, but generally after it is a month old, spots with a very slight, somewhat oily-looking, blackish colour begin to appear on the underside of the leaves, and especially

* A paper read at the Seventh Indian Science Congress, Nagpur, 1920.

Fig. 1. Typical attack of *Tambera* disease.

Fig. 2. Typical attack of *Tambera* disease.

on the younger foliage. These spots turn reddish, extend in area and in number very rapidly, and ultimately become a bronze colour, giving an almost uniformly reddish tinge to the leaves. The upper foliage of the plant acquires a bunched-up appearance, the edge of the leaves becomes wrinkled and the leaf hairs become very prominent. Gradually, commencing from the top, the whole of the foliage withers leaving however the main stock still green and living, though it also ultimately becomes discoloured and withers (Plate XV, figs. 1 and 2). The plant endeavours to recover, by giving out a series of auxiliary shoots, which are, however, rapidly attacked and wither accordingly. All these stages only require from thirteen to fifteen days from the beginning to the final ruin of the plants. The attack usually occurs after the tubers are formed and when they are about the size of a walnut. They cease, however, to develop further and hence the yield consists of a very small weight of very small potatoes.

At first a few single plants are attacked, but from these the disease spreads in patches until the whole fields are affected. This spread is very rapid. As an example, a patch of potatoes which was carefully watched in 1919 may be described. The whole patch of potatoes was thirty-three feet square. On the first day only four plants could be detected with the disease, three near one corner and another nearer the centre of the field. Five days later, the whole of the corner of the field round the former plants and a large circular patch round the latter were obviously attacked. Three days after, the whole field was affected except a narrow strip down the middle, while on the thirteenth day from the commencement, the field was red and withering from end to end. The disease comes on almost as if a fire is passing through the fields and is universally attributed by the cultivators to the prevalence of light, misty rain which often occurs during the months of August and September.

It is obvious that a disease like this is of very great importance, and it indeed appears to be the factor which limits the spread of the cultivation of potatoes during the *kharif* season in Western India. It has now been found not to be limited to the Poona potato area, but also occurs in other districts and even in Sind.

It has been noticed in the *rabi* (winter) crop also, but there it never does any serious harm and it may be almost ignored.

All attempts to trace the immediate cause of the disease for a long time proved futile. Fungus diseases were absent, and no trace of a bacterial affection could be found. Everything indicated that the attack was due to a parasitic attack of some sort, but it was not until 1919 that the nature of the parasite was discovered. At that time our attention was drawn to a disease which appeared to be of a very similar kind reported from Hawaii in 1917[1] and which was attributed to the work of a mite. The appearance shown in the illustrations of the disease seems to agree very closely with that shown in *tambera* and hence a careful search was at once made for the very minute mites described. We had already been able to produce the disease at will by growing the potato plants under conditions of high temperature, and on examination they were found to be swarming with mites exactly similar in character to those found in Hawaii.

These mites are found on all the affected parts, especially on the under-surface of the leaves of the plants. They are so small as to escape notice with the naked eye, until the eye is trained how to look for them, and even with a hand lens unless carefully looked into. They can, however, be easily seen in all stages under the microscope with a low power. The eggs are peculiar sculptured bodies rounded oval in shape, and firmly attached to the leaf. The egg cases, even after the emergence of the larvæ, persist for a long time as colourless, transparent objects, still retaining the sculpturing in the form of rows of small opaque white globules. The young mites are hyaline, have three pairs of legs and are sluggish. The moult and the skins thrown off by them are seen in great numbers, as white specks. The adult female is a clear amber colour, with smooth glistening skin, and has a fourth pair of legs which are much thinner than the remaining ones. It is an oval active creature moving about on six legs while the other two are dragged behind, and measures one-fifth by one-tenth millimeter. The male is of the

[1] Carpenter, C. W. "A new disease of the Irish potato." *Phyto-Pathology*, Vol. VIII, p. 286 (1918).

same colour with a brownish tinge, but is quite different in size and shape. It is more orbicular and smaller, measuring one-tenth by one-eleventh millimeter, with a clouded dorsal spot, and it possesses strongly developed legs and is much more active than the female. The first pair of legs has two joints, the second and third pairs have five joints and the fourth pair has four joints and each joint bears a few hairs.

The mites apparently suck up the juice from the epidermal cells of the leaves with the result that the leaves are unable to stand the heavy drain on them and wither prematurely. The mites then leave such leaves and go in search of fresh leaves which they easily reach by crawling over from plant to plant as the plants touch one another. Whether they are, like some other mites, carried by insects or other agencies is not known.

The naming of the mites is the work of a specialist. Carpenter does not attempt it. He makes a formal statement that they may belong to the same group as the so-called red-spider (*Tetranychidæ*).

The mere presence of the mite is not, of course, sufficient to enable us to attribute *tambera* disease to it unless the connection is proved by actual inoculation experiments. Carpenter in his paper does not record any experimental evidence, but bases his conclusions on the mere presence of the mites. He states as follows :— "That these minutest organisms are responsible for the disease seems evident. They are present in sufficient numbers on the plants with the recognized symptoms to warrant this conclusion and the reaction of the plant is such as we have come to associate with mite injury. Furthermore, if the mites be kept off a portion of the plants by spraying or dusting with sulphur those so protected develop normally while adjacent unprotected plants are devastated."

The following inoculation experiments were, however, carried out. At first only two plants in pots were brought into the laboratory and on being convinced that they were quite free from the mite attack one was used for inoculation and the other as control. Inoculation was made by putting on the plant to be inoculated affected shoots from a diseased plant containing mites. The inoculated

plant began to show the symptoms on the third day. On the fifth day these were quite clear and on the eighth day the withering of leaves commenced (Plate XVI, fig. 1). The control plant kept away from the inoculated one did not show any of the symptoms and remained quite healthy (Plate XVI, fig. 2). Encouraged with this trial, experiments were made on a greater number of plants. Ten plants were raised in pots. Five were used for inoculation and five for control. Inoculation of the plant was done as before on the 5th of August, 1919, by placing on them the affected shoots containing mites. The plants began to show the disease on the next day, and on the fourth day the symptoms were quite evident, namely, the bunching of shoots and the browning of the under-surface of tender leaves. At this stage the examination of a browned leaf under the microscope showed any number of moving mites with their eggs. On the eighth day the shoots were completely bunched up and were much darkened in colour. In one plant leaves were withering. Thirteen days later, most of the top leaves of all plants were quite reduced in size and dried up. The controls remained quite healthy during this period. The results of the experiments conducted in the same way, in the fields too were quite conclusive. Leaves affected and covered with mites were attached to a few plants in a corner of a plot where there was no disease and the plants were kept under observation. The inoculated plants alone took the disease and the attack started from the point of contact with the affected leaves. The mites were again found in intimate association with the disease on the new plants.

The casual connection of the mites with the disease at once suggested a method of control, by spraying with a sulphur wash, or by dusting with sulphur, and preliminary trials were made in pots where the potatoes were seriously affected. Both methods proved effective, and it was found possible to revive plants which were in a very advanced stage of the disease. Experiments on small plots proved equally effective.

The potato crop is so valuable that the application of such a spraying method as a safeguard against the disease would pay well, and hence a limited area in the fields of the cultivators has been

Fig. 1. Plants inoculated with *Tambera* mite.

Fig. 2. (1) Plant inoculated with *Tambera*; (2) Control plant without inoculation.

sprayed with lime sulphur wash, or dusted with sulphur, during the past season, three dressings being given commencing from the time when the plants were three weeks old. The results were excellent and a demand at once arose from the people to spray their whole area. The season and the disease had, however, by that time advanced so far that it was impossible to do anything this year. Spraying with lime sulphur wash, however, was a little more effective than dusting with sulphur. Three treatments were given—the first when the plants were three weeks old, the second when about six weeks, and the third when they were between two and three months from planting. The difference between the yield of the sprayed fields and those unsprayed in the immediate neighbourhood in 1919 was very great. The yield of the unsprayed plot was only 1,000 lb. per acre, or practically the amount of seed used; that of a plot sprayed after the attack commenced was 5,000 lb. per acre; that of a plot sprayed from the beginning was 8,720 lb. per acre. The cost of the complete spraying treatment this year was Rs. 13 per acre, but this can be materially reduced. At present, spraying, though more effective, is a new process to the cultivators, and it is probable that dusting with sulphur from muslin bags will be more generally used.

An attempt has been made to see if any of the varieties available are immune to the disease. All those commonly cultivated are, however, rapidly attacked if conditions are favourable. An English variety, "Epicure," in experimental trials seemed to possess some resisting power, but further experiments are necessary with it. The favourite variety in Poona, a round, white, Italian type, known in Western India as "Talegaon," was the first to be attacked, and the other local varieties soon followed.

It is difficult to say how the mites which cause the disease are carried over from year to year. Looking to the field conditions of the tract where these observations have been made, it appears that the disease may possibly be carried over on the potato plant itself. Although there are two definite seasonal crops, the *kharif* and the *rabi*, with regular intervals, the seasons are not sharply defined and potato cultivation goes on practically uninterruptedly between

June and March. The *kharif* crop is sown in June and July and is harvested in September and October, sometimes even in November. The sowing of the *rabi* crop begins in November and extends even up to March, the harvesting of very late planted crops coinciding with the planting of the *kharif* crop again. Stray plants arising from the remnant tubers of the previous crop are also found in the fields. It is thus seen that the potato plants are found throughout the year in the tract either as a regular crop or as stray plants, and the *rabi* crop though not seriously attacked is not by any means free from the mite. Owing to the cold weather the disease never does much damage and hence does not attract attention. The mite, however, comes into activity again as soon as the hot weather sets in in April and May. From the hot weather crop it is probably carried to the *kharif* season again.

Another possibility, of course, is that the mite may have other host plants. So far we have found what appears to be the same mite on *guvar* (*Cyamopsis psoralioides*) only. On this plant it has been recorded from Baroda, Padra, Surat, and Poona. Cross-inoculations have proved that the *guvar* mite and the potato mite are one and the same. Potato plants when infected with the *guvar* mite easily took the disease. Chilli and tomato plants were also tried, but they remained free from the disease. More observations and experiments are required on this point.

THE BIOLOGICAL ASPECTS OF WHEAT CULTIVATION ON EMBANKED SOILS.*

BY

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I. INTRODUCTION.

A PECULIAR TYPE of *rabi* cultivation for wheat is carried on in the Haveli tract in the north of the Central Provinces. The system has been fully described by Mr. Evans [1] when Deputy Director of Agriculture, Northern Circle, Central Provinces, so a detailed description of the agricultural practice is unnecessary. It may, however, be stated that the usual *rabi* crops—wheat, gram, *teora* (*Lathyrus sativus*), *masur* (*Lens esculenta*), linseed, etc., either pure or in mixture—are grown in a soil which for the greater part of the monsoon months is water-logged. Banks or *bunds* are erected on any level fields and the monsoon rainfall is impounded. The average rainfall in the tract is 50–60 inches. During the hot weather one single cultivation may or may not be given. The fields are allowed to be flooded, and in the month of October the water is run off. As the field dries, seed is sown with a plough (*nari*) and here again a preliminary cultivation may or may not be given. The

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* Paper read at the Seventh Indian Science Congress, Nagpur, 1920.

[1] *Agri. Journal of India*, Vol. VIII, 1913, p. 117.

average out-turn is about 700 lb. per acre of either wheat, gram, or *masur*. This brief outline of the system followed in this tract will show that the soil undergoes three distinct phases. There is the dry hot weather season when the soil frequently cracks to considerable depths. This is followed by a period when the soil is submerged by the monsoon rainfall and again by a growing season when the percentage of moisture in the soil gradually falls from full saturation to the hot weather state. It should be explained that the soil in itself is a particularly heavy one containing, as will be seen from the figures quoted in Table I, nearly 75 per cent. of clay and silt.

Our attention was drawn to these soils by Mr. G. Evans, Deputy Director of Agriculture, Northern Circle, Central Provinces, and by one of the leading landholders. It was stated that these soils are found to be gradually decreasing in fertility but the peculiarities of the agricultural practice followed, seemed to call for an examination of the bacteriological processes prevailing in the soil. It was also pointed out that the early growth of the wheat plant, by its dwarfed and yellow colour, indicated nitrogen starvation. It will be observed that no manure is applied to this land and the soil depends for its crop-producing power on natural recuperative processes for maintaining soil fertility.

It was further considered that saturation with water during most of the rainy season might possibly tend to diminish the power of the soil to render available the nitrogen contained in it.

II. Experimental.

Experimental plots were laid out in the year 1915-16 on land in the Haveli tract at Kheri near Jubbulpore. Three fields were chosen and cultivated as follows :—

Plot I was not surrounded by a *bund* or embankment and was ploughed in the beginning of the monsoon and harrowed at intervals during the monsoon.

Plot VI was kept flooded until one month before sowing time, when the water was drained off and one harrowing given before sowing.

Plot VII followed the usual practice. It was kept flooded as long as possible and not cultivated at all.

The three plots therefore represent the maximum aeration possible, partial aeration and no aeration.

The following analyses will show that mechanically the soils in the various plots were very similar.

TABLE I

Showing the physical analyses of the soil from the various experimental plots.

	Plot I	Plot VI	Plot VII
Clay	44·10	45·90	45·000
Fine silt	15·40	14·30	14·800
Silt	14·00	12·70	13·300
Fine sand	10·80	8·90	8·300
Coarse sand	2·80	5·70	4·100
Moisture	7·70	7·00	7·200
Loss on ingnition	5·56	5·73	6·940
$CaCO_3$	0·10	0·14	0·115
TOTAL	100·46	100·37	99·755

The analyses indicate that the soil is a heavy sticky clay. It is black in colour and needs to be cultivated at the proper time or the tilth is destroyed. The maximum saturation capacity, as determined by Hilgard's method, with a soil layer 1 c.m. deep, is about 60 per cent. by weight.

In the first year definite biological work was not possible, but samples of soil were taken at intervals between the beginning of the monsoon and harvest time and determinations of nitrogen as ammonia, nitrogen as nitrates, total organic nitrogen, humus, moisture and calcium carbonate were made.

A résumé of the results is given in Table II (p. 296).

The remarkable feature about these results is the small proportion of easily available nitrogen present in these soils. Further, the stock of nitrogen present in the soil to be drawn on for the future use of the plant is very small. This fact suggested that possibly the nutrition of the wheat plant on embanked land is very closely connected with seasonal bacterial activity in the soil and does not

depend to any great extent upon accumulated plant food stored up in reserve.

During the next season arrangements for bacteriological work were possible, hence a study of the bacterial activity in these soils was taken up. The usual biological analyses of the soils dealing with nitrogen fixation, ammonification, and nitrification, etc., were first carried out and some interesting results were obtained which can be summarized as follows :—

(1) The soils under experiment appear to be very energetic in nitrogen fixation, that is, they are able, to a more than common extent, to take up nitrogen from the air by bacterial processes.

(2) Having taken up this nitrogen, they have considerable ammonifying power, that is, they are able rapidly to break down organic nitrogen to the simpler form of ammonia.

(3) In the conversion of ammonia into nitrate, these soils appear to be distinctly weak, the oxidation only going as far as the nitrite stage, very little nitrate being formed. The figures obtained are tabulated in Table III at p. 297.

Having found from the previous year's results that these soils are of low nitrifying power, experiments were continued during the next year with certain additions. In the first place, a series of moisture determinations were made in order to see to what extent the various methods of treatment modified the water content of the soil. The first determination was made in October after heavy rains, and Plots I, VI, VII contained 35, 40, and 44 per cent. of water, respectively. This showed a considerable difference between the embanked plots but by the 10th November the figures had decreased to percentages of 23, 23, and 29 for the same plots. Further determinations were made in January in the middle of the growing season and the water content of all the plots was uniform at 17 per cent. These figures (Table IV) indicate that in a year of good rainfall an unembanked field is as good as an embanked one, as the soil can only hold a certain amount of water and the impounded water

upon the surface does not materially affect its water content at the important time of the season, that is, from November to February. If the rains stopped early, the moisture conditions of the various plots might be different. Apparently, about 20 to 25 per cent. of moisture is what the soil wants at sowing time.

It may be concluded that in a year of good rainfall no advantage accrues from embankments as regards the water content of the soil, but as no year of low rainfall has occurred during the course of the experiments, the authors are unable to give data for a very abnormal year.

In making observations of the power of the soil for nitrifying ammonium sulphate in Omeliansky's solution, it was noticed that nitrification progressed quickly at a temperature of 30°C., but at the lower air temperature prevailing during the cold weather, nitrification was very slow although it proceeded as far as the nitrite stage (Table III).

In soil medium, with oil cake as material to be nitrified, the same effect was noticed.

In this case, however, it was found that ammonification proceeded rapidly, about 33 per cent. of the organic nitrogen added being ammonified in a period of 15 days. The deficiency in nitrate forming power was not improved by the addition of reasonable quantities of calcium carbonate or copper sulphate[1] (Table V).

In all cases, only about 3 to 5 per cent. of organic nitrogen added to the soil was converted to nitrate within a period of 8 weeks.

The black cotton soil of the Deccan is of somewhat similar texture to the soils under experiment but is given an open cultivation and experiences a lower rainfall. From the figures quoted in Table V it will be seen that the nitrifying power of black cotton soil is very superior to that of Kheri soil even under similar conditions regarding water content, temperature, etc.

Incubation of the soil with the cake at 30–33°C. increased, however, the nitrifying efficiency to a very great extent, though it was much below the ordinary nitrifying capacity of black cotton

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[1] Lipman and Burgess. *Univ. Cal. Pub. Agri. Sci.*, Vol. 1, No. 6, pp. 127–139.

soil under similar conditions (Table VI). The maximum amount of nitrogen converted into the form of nitrate, within a period of 8 weeks, was only 50 per cent. in the case of Kheri soils as against 85 per cent. in the case of black cotton soil. Water content to the extent of 25 to 30 per cent. seems to be the optimum for nitrification for these soils (Table VII).

The wheat growing area in the north of the Central Provinces extends from Jubbulpore down to Hoshangabad, the whole area being known as the Narbada Valley. In Jubbulpore district the system of embankment is common, but it is not practised in Hoshangabad. In the latter district, the wheat soils are given good open cultivation. The rainfall of the two districts and the soils are not very dissimilar. It is also considered that varieties of wheat grown in Hoshangabad do not suit the conditions prevailing in Jubbulpore Haveli and *vice versâ*.

On determining the nitrifying power of Hoshangabad soil, it was found that it was very superior in this respect to Kheri soil (Table VI). The authors were, therefore, led to investigate the question whether by reason of the small amount of nitrate available in embanked land, wheats grown under such conditions were forced to take in their nitrogen in a form other than nitrate. Pot experiments were conducted at Nagpur in which Hoshangabad wheats were grown on their own soil and on soil from an embanked area, and Jubbulpore wheats on their particular soil and on soil from the open cultivation at Hoshangabad. At the same time the plants were manured with nitrogen either as nitrate or ammonia. Unfortunately with these heavy clay soils it was found almost impossible to obtain good conditions for growth in pot experiments and the results were not very convincing. It was however, noticeable that nitrogen as ammonia on soils from the embanked tract had a greater manurial effect than the same amount of nitrogen as nitrate. This was more marked with Kheri soils and Jubbulpore wheats than with Hoshangabad and Nagpur soils. The Jubbulpore wheats showed a marked preference for ammoniacal nitrogen particularly on Kheri soil but the Hoshangabad wheats did not evince such a definite partiality.

For the past two years, attention has been particularly paid to the changes which the soil may be undergoing in its nitrifying capacity, and the results will be found in Table VIII. It will be noticed that Plots I and VI show a nitrifying power greater than that of Plot VII, and apparently this nitrifying power is increasing. The results for the years 1917-19 bring out an interesting point indicating the intimate connection between laboratory experiments and field conditions. A bad tilth was obtained in that period and this exerted a depressing effect on both the nitrifying power and the yield of crop.

It was generally observed during the 4 years of experiment that the young plants in Plots I and VI did not show the yellow colour generally attributed to nitrogen starvation.

III. Summary.

1. It was brought to the notice of the Agricultural Chemist, Central Provinces, that the embanked wheat soils of Jubbulpore tract were said to be gradually deteriorating and giving low yields.

2. It was observed that wheat plants in such embanked fields appear weak and yellow in the early stage of their growth, but recover later on.

3. Mechanical analyses of the soil were carried out. The soil is heavy and sticky black in colour but less so than ordinary black cotton soil. It gets very hard and forms tenacious blocks on drying after rains.

4. Biological analysis shows that these soils possess very good power for ammonification and nitrogen fixation, etc., but are rather slow at nitrification.

5. The nitrifying power of the soil increases gradually when rainy weather cultivation is given to the soil.

6. The out-turn of wheat is also considerably increased when some form of rainy weather cultivation is given to embanked wheat soils and wheat seedlings from plots receiving cultivation do not appear yellow and weak in the early stage of their growth.

7. From the experimental results obtained it appears that young wheat plants in embanked fields are subject to some factor which retards their growth. This factor may be due to lack of

available nitrogen or the presence of some deleterious substance formed under anaerobic conditions. It is evident that whatever the cause it is removed by cultivation and aeration during the monsoon months.

8. Experiments with a more precise control over field trials are in progress with a view to determining the most economic form of cultivation. Attention will also be given to determine, if possible, the exact factor which interferes with the growth of young wheat seedlings on embanked soils.

9. Experience gained from this enquiry shows the difficulty of using pot cultures in very heavy soils such as that under experiment. It is impossible to reproduce field conditions in pots when the soil has to be transferred from field to pot culture house.

TABLE II

Showing the amounts of nitrogen as ammonia, nitrate, etc., in various plots.

Plots and samples	Nitrogen as ammonia	Nitrogen as nitrate	Total available nitrogen	Moisture	Carbonate of lime	Humus	Nitrogen
Plot I							
Sample A ..	0·00035	0·00020	0·00055	..	0·12	0·85	0·03
do. B ..	0·00015	0·00066	0·00081	15·34	..	..	..
do. C ..	0·00023	0·00021	0·00044	13·66	..	..	..
Plot VI							
Sample A ..	0·00045	0·00005	0·00050	..	0·14	0·94	0·03
do. B ..	0·00010	0·00053	0·00063	14·33	..	..	..
do. C ..	0·00024	0·00021	0·00045	14·82	..	..	..
Plot VII							
Sample A ..	0·00055	0·00023	0·00078	..	0·11	0·96	0·03
do. B ..	0·00005	0·00045	0·00050	15·67	..	..	..
do. C ..	0·00026	0·00031	0·00057	13·88	..	..	..

TABLE III

Showing nitrification of ammonium sulphate in Omeliansky's solution in mgm. at different temperatures. (100 c.c. dilute solution containing 10·6 mgm. nitrogen was employed.)

	LOWER TEMPERATURE OF THE ROOM						AT 30°C.					
	Plot I		Plot VI		Plot VII		Plot I		Plot VI		Plot VII	
	Nitrite	Nitrate	Nitrite	Nitrate	Nitrite	Nitrate	Nitrite	Nitrate	Nitrite	Nitrate	Nitrite	Nitrate
1st week	5·10	..	traces	..	traces	..	3·85	..	1·78	..	1·49	..
2nd week	1·43	1·43	1·43	..	1·36	..	8·90	..	8·00	..	8·00	..
3rd week	3·57	3·71	3·71	..	3·57	..	9·60	0·85	9·20	..	9·20	..
4th week	8·21	8·21	8·21	..	8·90	..	..	8·54	..	6·40	..	6·83
5th week	9·90	..	8·50	..	7·82	..	..	9·40	..	7·68	..	8·11
6th week	9·90	0·34	10·70	0·26	11·40	0·26	..	..	..	..	..	..

TABLE IV

Showing percentages of moisture in the various Kheri plots in various years.

YEAR 1915–16		YEAR 1916–17			YEAR 1917–18	YEAR 1918–19	REMARKS
Date of sampling		Date of sampling			Date of sampling	Date of sampling	
31-10-15	1-1-16	20-10-16	10-11-16	26-1-17	20-10-17	30-10-18	
15·34	13·66	34·6	22·9	16·60	25·6	16·9	In the year 1918-19 the samples were taken late owing to unavoidable reasons. Due to absence of late rains sowing was done rather earlier. The plots however received sufficient rain just in the right time when the plants were about 6 inches high.
14·33	14·82	39·7	22·6	17·20	30·9	14·6	
15·67	13·88	43·9	28·9	16·60	31·6	20·0	

TABLE V

Showing nitrification of cake in Kheri and black cotton soil at lower temperature with and without addition of substances like chalk, copper sulphate, etc. (Cake supplied at the rate of 60 mgm. per 100 gm. of the dry soil.)

	SOIL AND CAKE						SOIL + CAKE + CALCIUM CARBONATE 1 %						SOIL + CAKE + COPPER SULPHATE ·1 %						SOIL + CAKE	
	Plot I		Plot VI		Plot VII		Plot I		Plot VI		Plot VII		Plot I		Plot VI		Plot VII		Black cotton soil	
	% N as NH_3	Total % N nitrified	% N as NH_3	Total % N nitrified	% N as NH_3	Total % N nitrified	% N as NH_3	Total % N nitrified	% N as NH_3	Total % N nitrified	% N as NH_3	Total % N nitrified	% N as NH_3	Total % N nitrified	% N as NH_3	Total % N nitrified	% N as NH_3	Total % N nitrified	% N as NH_3	Total % N nitrified
2 weeks ..	31·10	-	23·20	-	26·00		33·60	—	24·2	-	28·00	-	23.2	Minute traces	18·60	Minute traces	23·2	Minute traces	29·74	2·12
4 weeks ..	32·53	—	31·10	-	27·89	-	32·60	traces	33·6	-	32·60	—	31·1	1·30	25·10	1·06	28·0	1·30	12·08	54·03
6 weeks ..	31·64	5·230	30·71	..	32·53	-	15·12	5·4	16·8	—	18·72	...	27·0	2·55	30·71	1·30	33·6	traces	0·93	76·74
8 weeks ..	24·17	0·801	25·10	2·54	31·64	traces	22·40	11·2	25·1	6·5	26·13	traces	26·3	3·40	24·20	1·69	28·9	1·69	1·86	82·96

TABLE VI

Showing nitrification of cake in Kheri black cotton and Hoshangabad soils incubated at 30°C. (Cake = 60 mgm. nitrogen per 100 gm. dry soil employed.)

	Plot I		Plot VI		Plot VII		Black cotton soil		Hoshangabad soil	
	% N as NH_3	Total % N nitrified	% N as NH_3	Total % N nitrified	% N as NH_3	Total % N nitrified	% N as NH_3	Total % N nitrified	% N as NH_3	Total % N nitrified
2nd week ..	41·0	—	38·2	traces	39·2	traces	18·6	54·0	40	13·68
4th week ..	28·0	21·0	28·0	17·8	31·1	10·8	3·7	81·3	—	31·00
6th week ..	23·2	26·7	23·2	21·5	15·8	23·5	2·8	76·8	—	64·00
8th week ..	16·8	42·8	14·8	42·8	9·3	46·9	0·9	85·4	—	76·80

TABLE VII

Showing nitrification in Kheri soil Plot I at different saturations at 30°C. (Cake = 60 mgm. nitrogen per 100 gm. dry soil employed.)

	1/3 saturation = 20 % Moisture		3/8 saturation = 22·5 % Moisture		1/2 saturation = 30 % Moisture	
	% N as NH_3	Total % N nitrified	% N as NH_3	Total % N nitrified	% N as NH_3	Total % N nitrified
2 weeks	33·60	0·41	34·39	0·41	36·25	0·53
4 weeks	37·18	1·20	34·39	7·08	26·13	20·26
6 weeks	41·00	4·56	30·71	14·39	22·40	27·72
8 weeks	38·31	8·26	25·10	29·88	13·01	51·09

TABLE VIII

Showing the rate of nitrification in different plots in different years in sampled soil with 60 mgm. nitrogen as cake and optimum moisture content. (Soils were incubated at 30°–33°C. Amount of nitrogen nitrified is represented in terms of percentages and includes both nitrite and nitrate nitrogen found.)

	1915–1916			1916–1917			1917–1918			1918–1919			REMAR
	Plot I	Plot VI	Plot VII	Plot I	Plot VI	Plot VII	Plot I	Plot VI	Plot VII	Plot I	Plot VI	Plot VII	
After 2 weeks	*Nil*	*Nil*	*Nil*	traces	traces	traces	2·66	7·40	6·60	3·4	1·3	1·4	In the yea 18 the of Plot spoilt d untimely vation r in the tion of hard clo that in I and VII not quit
„ 4 weeks	9·8	2·5	2·5	21·0	17·8	10·8	5·32	10·66	8·53	13·9	8·9	7·7	
„ 6 weeks	15·5	14·8	13·8	26·7	21·5	23·5	6·40	19·20	14·92	27·7	21·6	17·7	
„ 8 weeks	25·6	27·6	21·3	42·8	42·8	46·9	15·96	29·84	21·32	38·4	42·7	29·9	

TABLE IX

Showing average out-turn of wheat grain per acre in lb.

Plot I	683
Plot VI	679
Plot VII	562

Selected Articles

THE FUTURE OF WHEAT PRODUCTION WITH SPECIAL REFERENCE TO THE EMPIRE.*

In view of the importance of the question of the future of wheat production, the present article has been prepared by Mr. A. S. Judge, lately Chief Collector of Customs, Burma, from published information and material available at the Imperial Institute.

WHEAT IN RELATION TO OTHER CEREALS.

In dealing with the question of the consumption and disposal of the wheat crops of the world, it is essential that those of other cereals should be taken into consideration, for in times of shortage these grains are substituted for wheat, and some of them provide the staple food of the inhabitants of various parts of the world.

World's production of cereals.

Wheat and rice are the two principal cereals which provide food for mankind; millets, rye, maize, barley, and oats, especially the first three, are used as human food in many countries, but are more generally used in Western countries for feeding live-stock. The annual production of wheat in the world amounts to about 110,000,000 tons, while that of rice, assuming that the out-turn in China is equal to that of India, is about 90,000,000 tons. Rice is the staple food of the majority of the inhabitants of India, China, Siam, Japan, Korea, Formosa, the Philippine Islands, Ceylon, and the Malay Peninsula and Archipelago; it may be estimated that more than one-third of the human race are rice-eaters. Wheat is the principal bread grain of the Western nations, and the world's production of this grain is almost entirely converted into flour, in the course of which process various by-products are obtained

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which are used as cattle food. Wheat provides food for the majority of the inhabitants of Europe, America, Australasia, Northern Africa, and of those parts of Asia where rice is not the staple food.

In Northern and Central Europe, black bread made from rye takes the place of wheaten bread among the poorer classes. The estimated production of rye in the world is about 45,000,000 tons, of which more than one-half is raised in Russia, and one-fourth in Germany. Rye is also grown in the United States, and during the war Scandinavian countries obtained their requirements of rye and rye flour largely from this source.

There is an increasing demand for wheaten flour throughout the world; it has been replacing rye in Europe, and in Germany the average consumption of wheat per capita advanced from 130 lb. for the ten years ending 1889 to 190 lb. for the ten years ending 1912; in Asia, Africa, and South America also natives prefer wheaten flour to their ordinary diet, and the demand for this flour will advance as the material prosperity of the people improves. It is fortunate, therefore, that vast tracts of virgin land are available for wheat-growing in Canada, Argentina, Australia, and Siberia, and that the old-world granary of Mesopotamia, after centuries of neglect and misrule, will again provide abundant supplies of food for mankind. The rice-lands in Eastern countries with their teeming populations have, on the other hand, nearly all been brought into cultivation, and although lands suitable for rice are available in Africa and America, it seems doubtful whether rice will be cultivated on an extensive scale in these countries.

The quantity of maize produced in the world is probably greater than that of wheat, and the demand for this grain is constantly increasing. Maize is a prolific crop: it is estimated that it takes a little more than half of the acreage laid down to wheat to provide the same yield of maize. The United States contribute at present about 70 per cent. of the total world's production; Argentina, Brazil, Mexico, Peru, India, Egypt, Russia, Rumania, Hungary, and Italy are also large producers, and British South Africa, with a suitable climate for this crop, promises in the future to supply large quantities of maize. In Europe and North America

maize is chiefly used for feeding live-stock, and the wonderful development of the pork industry of the United States is directly related to the maize crop. In parts of South America, Africa, Asia, and of Southern and Eastern Europe, maize provides food for the people. Although corn-flour is largely eaten in all civilized countries, this flour alone cannot be made into a light porous loaf, as can wheaten flour, owing to the difference in the character of its gluten.

Barley is an important crop in Europe, especially in Russia and Germany ; it is also extensively cultivated in North America, Northern Africa, Japan, China, India, and Asiatic Turkey. The annual production in the world cannot be short of 50,000,000 tons. In Europe and North America the grain provides food for cattle, and the best qualities are also largely used by distillers and brewers, the by-products which result forming valuable food for cattle. Barley is eaten, to some extent, by the inhabitants of Northern Africa, and also in parts of Asia ; its principal use is, however, as fodder for cattle. During the war, barley meal was used in most of the European countries for admixture with wheaten flour in the manufacture of bread.

The annual production of oats in the world is estimated at about 65,000,000 tons ; oats are raised principally in Europe and North America, mainly as food for cattle. An increasing quantity of oatmeal and other preparations of this grain is now being consumed throughout the world ; in 1918 the United States exported over 150,000 tons of oatmeal, rolled oats, etc.

Millets are grown extensively in Asia, Africa, and also in Russia and the Balkan States. It is not possible to frame any reliable estimate of the quantity of this grain produced in the world. In India 52,000;000 acres are devoted to millets, and the supply of human food obtained from this source is only of less importance than rice. In China also there is a large cultivation, and in Japan the estimated out-turn of grain is 500,000 tons. The production in Egypt is 250,000 tons, and millets are grown in many other parts of Africa. The production in Russia in 1912 was about 2,500,000 tons. During the same year Russia produced 1,200,000 tons of buckwheat. France and the United States each produced about

400,000 tons of this grain, which is also grown in other parts of the world.

World's consumption of cereals.

The following statement shows the average consumption per head of population, in certain countries, of wheat, rye, barley, oats, and maize for the five years 1909–13:

Country	Wheat	Rye	Barley	Oats	Maize	Total
	lb.	lb.	lb.	lb.	lb.	lb.
United Kingdom	360	3	115	181	99	758
France	493	64	61	292	59	969
Belgium	505	195	123	204	128	1,155
Netherlands	263	241	113	140	201	958
Denmark	245	500	409	622	238	2,014
Sweden	158	251	114	433	17	973
Russia	180	244	72	155	18	669
Spain	340	66	156	41	98	701
Italy	370	8	13	37	179	607
Germany	191	323	213	269	27	1,023
Austria	217	213	121	174	73	798
Hungary	310	84	120	105	479	1,098
Rumania	181	3	22	70	481	757
Canada	755	15	226	1,339	211	2,546
United States	319	18	81	349	1,564	2,331
Argentina	354	3	14	28	408	807
Japan	31	—	87	3	4	125
Egypt	191	—	46	—	311	548
Australia	328	—	28	116	125	597

The above statement has been prepared from the Statistical Notes published by the International Institute of Agriculture, Rome. The consumption covers not only human food, but also cereals required for feeding live-stock, and for industrial purposes; seed requirements are, however, excluded.

The consumption of rice in the Western countries of Europe and in America may be estimated at between 8 and 10 lb. per capita; the pre-war average in the United Kingdom was 8 lb., but latterly it has been twice as great. In Italy and Spain, where rice is grown, the consumption is over 25 lb., and in Egypt it is over 50 lb. In Japan, where rice is the staple food of the people, the consumption is about 400 lb. In Italy, Russia, Egypt, and Japan millets and buckwheat are largely consumed.

There are no estimates showing the quantity of cereals required for human consumption in the countries mentioned above. It

may be estimated, however, that the average consumption per capita is 4 cwts. of grain, equivalent to about 300 lb. of flour or meal. The quantity of flour or meal obtained from grain varies according to the quality of the grain; it is, however, generally estimated that 133·3 lb. of wheat or barley, 153·8 lb. of rye, 166·6 lb. of oats, and 117·6 lb. of maize are required to produce 100 lb. of meal or flour. The amount of cereals consumed in different countries varies considerably: in France and Belgium, for instance, the mass of the people eat more bread and farinaceous food than those in England and America, who are accustomed to a more liberal meat diet. More wheaten flour is consumed in France and Belgium than in any other country, the high rate of consumption of wheat in Canada being due to the fact that in the past this grain was often given to cattle. An examination of the statement given above shows that wheat is the principal cereal consumed in the Western countries of Europe, whereas in the Central and Northern countries generally rye is more largely eaten than wheat. In Rumania wheat is extensively grown for export, maize being the chief diet of the people.

Source of European supplies of cereals.

The following table shows the average production of cereals in certain countries of Europe for the five years 1909–13 (1,000 tons):—

Country	Population	Wheat	Rye	Barley	Oats	Maize	Rice	Millets, buck-wheat, spelt	Total
United Kingdom ..	45,400,000	1,623	20	1,422	2,998	—	—	—	6,063
France ..	40,000,000	8,644	1,245	1,049	5,156	566	—	400	17,060
Belgium ..	7,500,000	405	580	94	618	—	—	—	1,697
Denmark ..	2,800,000	145	451	543	776	—	—	—	1,915
Spain ..	20,000,000	3,550	702	1,626	422	674	350	3	7,327
Italy ..	35,000,000	4,989	135	220	536	2,548	500	130	9,058
Germany ..	65,000,000	4,156	11,325	3,344	8,642	—	—	400	27,867

The average production, surplus of imports over exports, and consumption per capita of cereals in each country for the five years 1909-13 were as follows:

	Average production	Average surplus of imports over exports	Average consumption
	cwts.	cwts.	cwts.
United Kingdom ..	2·6	4·3	6·9
France	8·5	1·1	9·6
Belgium	4·5	6·2	10·7
Denmark	13·7	5·3	19·0
Spain	7·3	·4	7·7
Italy	5·1	1·1	6·2
Germany	8·5	1·6	10·1

Continental countries, as a rule, protect their agricultural industries by imposing import duties on cereals. In Germany the import duty on a quarter (8 bushels) of wheat was 11*s.* 10*d.*; in France 12*s.* 3*d.*; and in Italy 13*s.* The import duties in flour were on a higher scale. Belgium and Denmark admitted wheat free of duty.

The above table shows how dependent this country is on imported grain. With the exception of Norway and Finland, no other country in Europe is so dependent on outside supplies. Denmark, in proportion to her population, imports a greater quantity of grain than the United Kingdom; this is due, however, to the fact that her live-stock industry is relatively much more highly developed. The following table shows the number of live-stock in the two countries in 1912:

	Cattle	Sheep	Pigs
	No.	*No.*	*No.*
United Kingdom ..	11,914,635	28,967,495	3,992,549
Denmark	2,253,982	726,879	1,467,822

The estimated number of poultry in Denmark was 13,000,000, for the feeding of which a large quantity of cereals would be required.

The number of live-stock in the two countries for every thousand inhabitants is as follows:

	Cattle	Sheep	Pigs
	No.	*No.*	*No.*
United Kingdom ..	262	638	88
Denmark	804	259	524

In Great Britain for every 100 acres under crops or grass there are on an average 23 head of cattle, and in Ireland 34; in Denmark the number is 32, and in Belgium, before the war, there were 42. Taking cows and heifers only, there are in Great Britain 9·5, and in Ireland 11, to each 100 acres; whereas in Denmark and Belgium, before the war, the number was twice as large as in Great Britain.

The belief appears to obtain in some quarters that the choice of farmers in this country lies between wheat and milk. It has been maintained that the breaking up of grass-lands for cereals will result in the reduction of the number of cattle. This has not been the experience of farmers in Denmark, where there is very little pasturage and yet the head of cattle is, in proportion to the cultivated area, greater than in England. Corn and live-stock are not competitive products, unless cereals are grown on a large scale for sale, leaving no home-grown keep for animals. In Denmark less than 8 per cent. of the cereals grown consists of wheat, whereas in Great Britain the percentage of wheat to other cereals is nearly 30 per cent. Now that the national emergency has passed, and large supplies of wheat are available in Canada and other British Dominions, the question arises whether the cultivation in this country of oats and green crops for feeding stock would not pay better than wheat. In considering the relative advantages of growing wheat or oats, it should be borne in mind that the rates of ocean freight for oats are from 20 to 30 per cent. higher than for wheat, which is a heavier grain. The dairymen in this country rely principally on pasturage

during the summer months, whereas in Belgium and Denmark, where pasturage is limited, the farmers by intensive cultivation raise green crops for feeding cattle. For many years before the outbreak of war a decline in the acreage of arable land was a regular feature in the annual returns of agriculture in Great Britain. The reasons generally assigned for the reduction of arable land were the increase in the cost of cultivation, the growing scarcity of qualified labour, and the fall in prices of agricultural produce, due to the intensity of foreign competition. There is less risk and outlay involved in farming grass-land, and less labour is required; it is admitted, however, that a larger head of stock cannot thus be carried, and in fact that the number may be less than under a mixed system of farming.

The following table shows the average acreage under cereals and the average number of cattle and sheep in the United Kingdom over a period of years:

Period	Wheat	Barley	Oats	Total	Number of cattle	Number of sheep
	Acres	*Acres*	*Acres*	*Acres*		
1873 ..	3,670,000	2,574,000	4,198,000	10,442,000	10,153,000	33,982,000
1884–88 ..	2,543,600	2,349,100	4,314,900	9,207,600	10,614,000	29,351,000
1894–98 ..	1,853,600	2,232,500	4,335,900	8,422,000	10,924,000	30,467,000
1904–08 ..	1,675,000	1,903,300	4,206,900	7,785,200	11,660,000	29,747,000
1909–13 ..	1,888,300	1,847,300	4,061,200	7,796,800	11,849,000	30,016,000
1914–18 ..	2,238,700	1,737,400	4,529,300	8,505,400	12,298,000	28,239,000
1914 ..	1,906,000	1,873,000	3,899,000	7,678,000	12,184,000	27,904,000
1918 ..	2,793,000	1,839,000	5,605,000	10,237,000	12,451,000	28,849,000

Although in 1917 the cultivated area in Ireland represented 31 per cent. of the total acreage under crops and grass in the United Kingdom, her share of the total acreage under wheat was only 6 per cent., of barley 10 per cent., and of oats 30 per cent. Ireland possessed, however, 40 per cent. of the total head of cattle and 13 per cent. of the sheep. In 1918 both the acreage under cereals

and the number of cattle in the United Kingdom were greater than in any year for the last thirty-five years. England is one of the few countries in Europe where the number of sheep has been maintained in recent years. In most of the Continental countries sheep have decreased as the area of arable land has increased, and the same tendency is noticeable in the more closely settled districts of Australia and Argentina.

The value of farm and dairy produce imported into the United Kingdom is very large, and much of it comes from Denmark. The total value of imports of eggs, butter, and bacon in 1914, with the share of Denmark in the trade, was as follows:

	Total value of imports	Share of Denmark
	£	£
Eggs	8,652,800	2,546,979
Butter	24,014,276	11,038,637
Bacon	18,225,568	9,936,454
Total ..	50,892,644	23,522,070

With closer settlement on the land and more intensive cultivation it should be possible to increase largely the home supplies of farm and dairy produce.

The average net imports of cereals (flour and meal being reduced to grain) into countries in Europe for the five years 1909–13 are shown in the following table:

	Wheat	Rye	Barley	Oats	Maize	Total
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
United Kingdom ..	5,880,000	30,000	1,046,000	963,000	2,047,000	9,966,000
France ..	1,188,000	81,000	132,000	433,000	503,000	2,337,000
Belgium ..	1,340,000	124,000	330,000	119,000	438,000	2,351,000
Netherlands ..	598,000	293,000	241,000	117,000	552,000	1,801,000
Denmark ..	171,000	208,000	3,000	66,000	298,000	746,000
Norway ..	104,000	262,000	99,000	10,000	30,000	505,000
Sweden ..	191,000	97,000	—	66,000	42,000	396,000
Spain ..	168,000	—	—	-	247,000	415,000
Italy ..	1,448,000	16,000	18,000	118,000	368,000	1,968,000
Switzerland ..	460,000	18,000	25,000	181,000	101,000	785,000
Germany ..	1,859,000	—	3,245,000	47,000	812,000	5,973,000
Austria ..	1,397,000	316,000	91,000	191,000	594,000	2,589,000
Total ..	14,804,000	1,445,000	5,230,000	2,311,000	6,032,000	29,822,000

The principal exporting countries of the world for the five years 1909–13 were as follows:

	Wheat	Rye	Barley	Oats	Maize	Total
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Russia ..	4,467,000	707,000	3,769,000	1,005,000	711,000	10,659,000
Germany ..	—	671,000	—	—	—	671,000
Hungary ..	1,111,000	348,000	252,000	159,000	219,000	2,089,000
Rumania ..	1,460,000	96,000	390,000	141,000	1,138,000	3,225,000
Bulgaria ..	302,000	49,000	40,000	1,000	234,000	626,000
Canada ..	2,580,000	—	119,000	238,000	—	2,937,000
United States ..	2,910,000	24,000	180,000	64,000	924,000	4,102,000
Argentina ..	2,586,000	7,000	16,000	617,000	2,940,000	6,166,000
British India ..	1,349,000	—	226,000	—	20,000	1,595,000
Algeria ..	144,000	—	114,000	58,000	—	316,000
Australia ..	1,345,000	—	2,000	—	—	1,347,000
Total ..	18,254,000	1,902,000	5,108,000	2,283,000	6,186,000	33,733,000

The United States and Argentina send large quantities of wheat and flour to countries outside Europe; in other respects the trade was mainly with Europe. It will be seen that the importing countries in Europe obtained 55 per cent. of their requirements from other European countries, of which Russia supplied 35 per cent. and Rumania 11 per cent. During the war the Western countries of Europe could not draw on Russia or Rumania; this shortage was, however, largely made good by much heavier imports from the United States and Canada, as the following table will show:

AVERAGE EXPORTS FROM THE UNITED STATES AND CANADA—1914-15 TO 1917-18.

	Wheat	Rye	Barley	Oats	Maize	Total
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Canada ..	4,712,000	19,000	222,000	663,000	—	5,616,000
United States ..	5,576,000	346,000	526,000	1,512,000	1,172,000	9,132,000
Total ..	10,288,000	365,000	748,000	2,175,000	1,172,000	14,748,000

In 1917–18 the Union of South Africa exported over 200,000 tons of maize, and Brazil nearly 240,000 tons.

VARIETIES AND QUALITIES OF WHEAT.

There are many varieties of wheat grown in the world. All the best wheats grown, however, fall under the group "Common Wheats." The grain of the common bread wheat varies both in colour and quality, and may be either soft or hard. Soft wheat, termed "weak" by the miller, generally yields flour which makes a somewhat small loaf of dense texture; hard wheat, termed "strong," makes a larger and a porous loaf. As flour manufactured from hard wheat will carry a large percentage of moisture, a greater number of loaves of equal weight can be made from a given quantity of this flour than from the same quantity of flour obtained from soft wheat. The dense-eared types with weak grain give a heavier yield per acre than the hard wheats, and on this account they are largely cultivated in England, France, Germany, and in many of the older and closely settled countries. In countries with severe winters, high summer temperature and low rainfall, strong varieties with low yields are grown. The best descriptions of hard red wheat are produced in the United States, Canada, and Southern and Eastern Russia. Generally speaking, the question of strength or weakness of grain is dependent on the variety grown, and upon soil and climate; high summer temperature and low rainfall favour nitrogen content and flintiness; cooler and damper climates, on the other hand, favour starch production. It has been maintained that very high yield and superior strength could not be contained in the same variety; recent experiments made by the Agricultural Departments in India have proved, however, that this view is not correct, as excellent results, both as regards yield and quality, have been obtained from some new types which have been created by selection and cross-breeding and distributed among the cultivators in India. The average quality of home-grown wheats is low, and as wheats of the highest quality can be produced in England, efforts are now being made to obtain new varieties of prime quality and high yielding capacity. In recent years the standard of excellence

of flour has been raised, and there is a constant tendency towards the use of hard red wheats, with the result that the proportion of such wheats now grown in the world is much larger than it was twenty years ago.

Wheats of widely different characteristics are required by British millers, and home-grown wheat is nearly all mixed with Canadian and other foreign wheats, containing a high percentage of nitrogenous matter, to give the right proportion of milling and baking qualities for our bread-eaters. In many mills flour is never made from one straight lot of wheat; sometimes as many as four or five different lots are blended to obtain a well-balanced product. The chief constituents of flour are starch and gluten (albuminoids), which are found in an average proportion of 88 per cent. of starch and 12 per cent. of gluten. The gluten may be as low as 6 or 8 per cent. in soft wheats, and as high as 15 per cent. in hard wheats. The highest gluten content is possessed by the light-amber wheats of the durum group, which are grown extensively in Southern Europe and Northern Africa, and also in North America and Southern Russia. From the flour of this wheat macaroni and similar Italian pastes are prepared. The flour extraction of wheat varies in accordance with the quality of the grain. In America it is estimated that a good sample of Kansas Turkey wheat, a hard winter wheat, properly milled, will yield products approximating the following percentages: bran 12 per cent., shorts 14 per cent., total flour 72 per cent., which allows 2 per cent. for wastage and evaporation of moisture. Since the middle of the nineteenth century the milling process has been made much more efficient, partly by the substitution of rollers for millstones, and partly by improvements in arrangements for cleaning the grain and sorting out the various products obtained at different stages of the process. In normal times the average yield of flour from wheat in England is about 70 per cent., with about 28 per cent. of bran and pollards in nearly equal proportions. Usually two kinds of flour are made from one mixture. In Hungary and other parts of the Continent, where a dark flour can be sold or mixed with rye flour, yields as high as 75 and 78 per cent. are obtained, and several grades of flour are made. During the war

the flour extraction prescribed in this country varied with the quality of the wheat, but at first 81 per cent. was the standard, raised successively to 83, 88, and finally to 90 per cent. for some qualities. In Algeria the flour extraction for soft wheat was at first fixed at 74 per cent., and for hard wheat at 81 per cent. From March 1, 1917, the flour extraction in Germany was as high as 94 per cent.

THE PRODUCTION AND DISTRIBUTION OF WHEAT IN THE WORLD.

Wheat has a range of cultivation in the world, both as to elevation and latitude, greater than that of any other cereal. It is now grown successfully in the tropics and near the Arctic Circle. According to the estimates framed by the International Institute of Agriculture, Rome, the average area under wheat for the five years 1909–13 was about 250,000,000 acres, and the average yield of grain about 100,000,000 tons. These estimates do not include, however, the statistics for Serbia, Albania, Montenegro, Thrace, Greece, Finland, and Portugal in Europe, and only relate to returns from a part of Asiatic Russia and from India and Japan in Asia, to the Union of South Africa, Algeria, Tunis, and Egypt in Africa, and to the United States, Canada, Argentina, Uruguay, and Chile in America. The European States omitted from the returns produce close on a million tons of wheat. China, Persia, and Asiatic Turkey are all large producers, but unfortunately no reliable statistics are available. It has been estimated that 7,500,000 acres are devoted to wheat in the Ottoman Empire, and the production may be estimated at over 3,000,000 tons. Before the war Turkey was exporting both wheat and flour, and with more settled conditions and improved communications a great expansion may be expected in this direction. The Persians, like their neighbours in Turkey, are largely bread-eaters, and not only supply their own requirements, but are able to export small quantities of wheat. Wheat has been grown in China from the most ancient times, and the production must be very large, as it has been estimated that one-third of the population of China does not eat rice. Wheat is grown in nearly every province

in China, and is the staple food in the north. Travellers in many parts of China have recorded the fact that fields of wheat are the most common feature in the landscape. According to American Consular reports, Manchuria raises about 10,000,000 bushels of wheat, and is capable of producing 300,000,000 bushels. Wheat is grown extensively in Morocco, and in normal times the exports exceed 30,000 tons; in Abyssinia wheat is the staple food of the people. In Mexico and Brazil wheat is cultivated, and the production is increasing. It may be fairly estimated that wheat throughout the world at the outbreak of the war occupied 275,000,000 acres, and supplied about 4,000,000,000 bushels or 110,000,000 tons of grain. After deducting the seed requirements, which may be estimated at 11,000,000 tons, on the basis of 100 lb. of seed to the acre, there would be available as food approximately 100,000,000 tons of wheat, equivalent to about 75,000,000 tons of flour.

In the Northern Hemisphere the wheat harvest begins in India in March, and continues in one country or other until September, the largest area being reaped in July and August. In December and January, Australia and Argentina gather their harvests. The world's harvest is usually reckoned as being finished in February.

The following table shows the production, imports, exports, and consumption of wheat in certain countries for the five years 1909-13. (The trade in flour, expressed in its equivalent weight of grain, is included.)

Country	Average production	Average surplus of imports over exports	Average surplus of exports over imports	Average consumption
	Tons	*Tons*	*Tons*	*Tons*
United Kingdom	1,621,000	5,880,000	—	7,501,000
France	8,644,000	1,188,000	—	9,832,000
Belgium	405,000	1,344,000	—	1,749,000
Netherlands	131,000	598,000	—	729,000
Denmark	145,000	171,000	—	316,000
Carried over ..	10,946,000	9,181,000	...	20,127,000

Country	Average production	Average surplus of imports over exports	Average surplus of exports over imports	Average consumption
	Tons	*Tons*	*Tons*	*Tons*
Brought forward ..	10,946,000	9,181,000	—	20,127,000
Norway	8,000	104,000	—	112,000
Sweden	220,000	191,000	—	411,000
Russia in Europe, excluding Finland	18,180,000	—		
Russia in Asia (9 Governments)..	4,000,000	—	4,467,000	17,713,000
Spain	3,550,000	168,000	—	3,718,000
Italy	4,989,000	1,448,000	—	6,437,000
Switzerland	90,000	460,000	—	550,000
Germany	4,156,000	1,859,000	—	6,015,000
Austria	1,655,000	1,397,000	—	3,052,000
Hungary	4,621,000	—	1,111,000	3,510,000
Rumania	2,389,000	—	1,459,000	930,000
Bulgaria	1,190,000	—	301,000	889,000
Canada	5,571,000	—	2,580,000	2,991,000
United States	18,688,000	—	2,910,000	15,778,000
Argentina	4,282,000	—	2,586,000	1,696,000
Uruguay	195,000	—	35,000	160,000
Chile	609,000	—	65,000	544,000
British India	9,573,000	—	1,349,000	8,224,000
Japan	657,000	110,000	—	767,000
Union of South Africa	148,000	161,000	—	309,000
Egypt	928,000	212,000	—	1,140,000
Algeria	952,000	—	143,000	809,000
Tunis	169,000	20,000	—	189,000
Australia	2,241,000	—	1,345,000	896,000
New Zealand	211,000	—	20,000	191,000
Total ..	100,218,000	15,311,000	18,371,000	97,158,000

The average production of wheat in Europe for the five pre-war years, assuming that the production of the European countries

not shown in the above table was 1,000,000 tons, amounted to 53,000,000 tons. The only countries in Europe producing surplus wheat for export were Bulgaria, Rumania, Serbia, Hungary, and Russia. The remaining countries in Europe imported 14,804,000 tons of wheat, of which 7,338,000 tons were supplied by the countries mentioned above, and 7,466,000 tons were obtained from over-sea sources, mainly from Canada, the United States, Argentina, Australia and British India. During the war the surplus wheat from Russia could not be exported, and owing to the disturbed condition of the country it is probable that production has been much reduced. Since the outbreak of the war a great change in the land tenure has occurred in Russia, Rumania, and Hungary. Before the war the land in Russia was largely held in communal or in private ownership, and agriculture on the privately owned land was of a more advanced character, and gave a higher yield. Commercial farming on a large scale had made considerable progress, and wheat cultivation had been rapidly increased. In 1904 it was estimated that 17,627,000 acres of the wheat acreage was in private hands, and 26,126,000 acres in communal ownership. Under the communal system the land is held in common ownership by the villages, and is distributed at certain intervals among the members of the community for individual cultivation. The redistribution of the land tends to discourage high cultivation and manuring, and there was a growing tendency for the richer peasants to rent land from their poorer neighbours. Since the revolution took place in Russia the peasants have apparently taken possession of the land, and if the large farmers, who worked on modern lines, are eliminated, it must follow that production will decline, as the peasants will at first be poorly equipped with capital and machinery. In Rumania and Hungary the large estates have to a great extent been broken up into small farms. Eventually the productivity of the land will undoubtedly be enhanced by the new system of farming, but it will be interesting to see what immediate result the change in the ownership of the land will have on the production of cereals on a large scale for export. It remains to be proved whether the small farmer can afford to grow wheat in these countries to the same extent

as the late landowners who farmed on an extensive scale, and made wheat their main crop.

The following table shows the average production of wheat for the four years 1914–17, compared with the five years 1909–13, in Allied and Neutral countries in Europe:

Name of country	1909-13	1914-17
	Tons	*Tons*
United Kingdom	1,621,000	1,772,000
France	8,644,000	5,814,000
Netherlands	131,000	143,000
Denmark	145,000	164,000
Norway	8,000	9,000
Sweden	220,000	234,000
Spain	3,550,000	3,744,000
Italy	4,989,000	4,466,000
Switzerland	90,000	106,000
Total ..	19,398,000	16,452,000

France and Italy both suffered by the invasion and occupation of their territories by the enemy. Outside Europe there was a great expansion in wheat cultivation, as the following statements will show:

Name of country	1909-13	1914-17	1918
	Tons	*Tons*	*Tons*
Canada . .	5,574,000	7,379,000	5,724,000
United States .. .	88,688,000	21,799,000	25,009,000
Argentina .. .	4,282,000	3,579,000	5,950,000
British India	9,573,000	9,448,000	10,337,000
Australia .. .	2,241,000	3,129,000	3,134,000
Total	40,358,000	45,334,000	50,154,000

The acreage under wheat in the above-mentioned countries in 1918 had increased by 31,000,000 acres, and was 27 per cent. larger than the average acreage for the five pre-war years. There is at the present time a sufficiency of wheat, even without the help of Russia, to meet the requirements of the world, and with an extended area under cultivation in many countries there should be no danger of shortage in the immediate future. The question of the transport and distribution of the crops is, however, a difficult one, and freight charges will be high for a long time.

The area under wheat, production, and yield per acre in various countries of the world during three periods are given in the following table. The statement is incomplete, as statistics regarding several wheat-growing countries are not available. It may be estimated, however, that the countries not represented produce about 10 per cent. of the total world's production.

Name of country	AREA SOWN Million acres			TOTAL HARVEST Million bushels			YIELD PER ACRE Bushels per acre		
	1881-90	1891-00	1909-13	1881-90	1891-00	1909-13	1881-90	1891-00	1909-13
United Kingdom ..	2·7	2·0	1·9	76	60	60	28	30	32
France ..	17·2	17·1	16·0	301	305	317	17	18	20
Belgium ..	0·6	0·5	0·4	18	16	15	30	33	37
Netherlands .., Denmark, Norway .., Sweden .., Switzerland ..	0·6	0·6	0·6	17	18	22	28	30	36
Russia-in-Europe ..	30·2	36·2	61·2	244	300	666	8	8	11
Portugal ..	0·7	0·7	0·9	7	7	8	10	10	9
Spain	9·0	9·1	9·5	100	92	130	11	10	13
Italy	11·3	11·3	11·6	118	123	183	10	11	16
Germany ..	4·7	4·9	4·8	104	125	153	22	25	32
Austria ..	2·7	2·7	3·0	43	43	60	16	16	20
Hungary ..	6·8	8·2	9·0	118	143	169	17	17	19
Rumania ..	3·4	3·7	4·6	42	52	88	12	14	19
Bulgaria ..	2·4	2·4	2·9	35	35	44	15	15	15
Serbia .., Greece .., Turkey-in-Europe	3·6	3·6	3·6	40	40	40	11	11	11
Total Europe ..	95·9	103·0	130·0	1,263	1,359	1,955	13·1	13·2	15
India	26·7	25·2	29·2	259	243	351	10	10	12
Russia-in-Asia (9 Governments) ..	8·4	10·6	9·5	74	100	120	9	9	12
Japan	1·0	1·1	1·2	13	19	24	13	17	20
Canada ..	2·3	3·1	10·5	38	55	204	16	18	19
United States ..	37·1	43·1	47·1	427	559	685	12	13	14
Argentina ..	2·0	5·7	15·0	24	65	147	12	11	10
Uruguay ..	0·4	0·6	0·8	4	6	6	10	10	7
Chile	0·9	1·0	1·0	12	14	21	13	14	21
Union of South Africa ..	0·2	0·3	0·7	2	2	6	7	7	9
Egypt	1·2	1·3	1·3	12	13	34	10	10	26
Algeria ..	3·1	3·2	3·5	21	24	35	7	8	10
Tunis	0·8	1·0	1·3	5	6	6	6	6	5
Australia ..	3·2	4·1	7·6	27	30	90	8	7	12
New Zealand ..	0·3	0·3	0·3	8	7	7	25	25	25
Total ..	87·6	100·6	129·0	926	1,143	1,736	10·5	11·3	13·4
Grand Total ..	183·5	203·6	259·0	2,189	2,502	3,691	11·9	12·0	14·1

One of the most important features in the above statement is the rapid increase in the area under wheat in European Russia. The average area sown advanced from 36,000,000 acres between 1891–1900 to 61,000,000 acres between 1909–13, and the average production rose from 300,000,000 bushels to 666,000,000 bushels. The extension of wheat cultivation had, moreover, by no means reached its limit when the outbreak of war checked further progress. The returns from Italy are also remarkable, as the increase of 60,000,000 bushels in the third over the second period was almost entirely due to the increase in the yield per acre. With the exception of Portugal, Serbia, Greece, and Turkey, regarding which countries reliable statistics are not available, every country in Europe obtained a higher yield per acre. Compared with the yields of 42 bushels per acre in Denmark, 37 bushels in Belgium, and 32 bushels in England and Germany, the average yield of 15 bushels per acre for the whole of Europe is low, but with more scientific methods of agriculture and improved seed there can be little doubt that better results will be obtained in the backward countries.

Outside Europe the greatest advance in wheat-growing has been made in the following countries :

	1891–00 Area sown	1909–13 Area sown	1918 Area sown
	Million acres	Million acres	Million acres
Canada	3·1	10·5	17·3
United States	43·1	47·1	58·9
Argentina	5·7	15·0	17·9
India	25·2	29·2	35·5
Russia-in-Asia	10·6	9·5	14·5*
Australia	4·1	7·6	11·0
Total ..	91·8	110·9	155·1

*Area sown in 1915.

There was a general improvement in the average yield per acre, which is, however, still very low in most of the countries. The crops in Australia suffer from drought, and in Argentina from drought and locusts, and in both these countries the average quantity of seed sown is only a little more than one bushel to the acre. In India rust is the chief enemy, and accounts for the low average yield. Rust is the most widespread and serious disease from which wheat suffers; neither spraying nor seed treatment have been successful in checking the disease. Rust-resistance varies greatly geographically, and depends also on the kind of rust: varieties resistant in one locality may not be so in another. Known rust-proof varieties are generally poor yielders, but by selection and hybridization some progress has been made in raising good-cropping rust-proof types of wheat in different countries.

That there has been a great improvement in wheat-growing is evident from the fact that, whereas the total area sown advanced by less than 25 per cent. in the third over the second period, the total production rose by nearly 48 per cent. In 1898 the late Sir William Crookes estimated that the wheat-growing countries could only add 100,000,000 acres to the wheat area of the world, and this additional area would produce 1,270,000,000 bushels, just enough to supply the world's requirements up to 1931. About half the allotted period had elapsed in 1913, and although only 50,000,000 acres had been added to the wheat area, the production had increased by 1,191,000,000 bushels, nearly equal to the total production estimated for the additional 100,000,000 acres. Since the outbreak of the war, further extensions, amounting to nearly 50,000,000 acres, have been added, and vast areas of new land are still available in Canada, Argentina, Brazil, Australia and Siberia. In the United States and European Russia further extensions can be made, and in Asiatic Turkey and Northern Africa under settled conditions and with improved communications much larger areas will be brought into cultivation. When the forecast was made in 1898 it was apparently not recognized that the North Western Provinces of Canada possessed some of the most favourably situated wheat-growing lands in the world, and that the great

sheep-runs of Australia and Argentina, with their scanty rainfall, were also suitable for wheat-growing.

It is difficult to estimate the total area of new land in the world which could be made available for wheat-growing; it must, however, be far in excess of the area now devoted to wheat. In Australia it has recently been estimated that the area, with over 10 inches of rain in the growing season, available for grain in New South Wales, Victoria, South Australia and Western Australia, is nearly 50,000,000 acres. There are also immense areas of good land situated in the drier zones of the four States mentioned above, which under irrigation or with improved methods of cultivation and improvement in drought-resisting wheats will eventually come under cultivation. In Queensland and the Northern Territory there are great areas of land, both within and outside the tropics, where climate and soil are quite suitable for wheat-growing. In South America new lands suitable for wheat-growing probably equal those available in Australia, and Canada and Siberia will eventually provide even larger areas for wheat. Not only are there large reserve areas of land available to meet the growing requirements of the world, but the average yield per acre is being steadily improved. Under ordinary agriculture and with improved types of drought and rust-resisting wheats there is every reason to expect that the present average yield of 13 bushels per acre will be doubled, and with intensive cultivation the yield could be trebled. The fears expressed in some quarters that there will be a wheat crisis before the end of this century are without foundation. It has been predicted that the maximum world's production of wheat will be 6,000,000,000 bushels, and that the earth may in the end be able to feed permanently 1,000,000,000 wheat-eaters. With an average yield of 26 bushels to the acre the existing wheat area of 300,000,000 acres would produce 8,000,000,000 bushels of wheat.

PRODUCTION AND TRADE IN THE CHIEF COUNTRIES OF THE WORLD.

United Kingdom. The following statement shows the wheat production and the quantities and values of wheat and flour imported since 1861.

Period	Average annual production of wheat	Wheat		Flour		Percentage of flour to total imports of wheat and flour	Average value of wheat per ton
		Average imports	Average value	Average imports	Average value		
	Tons	*Tons*	£	*Tons*	£		£ s. d.
1861-75 ..	3,000,000	1,724,000	20,087,000	252,000	4,041,000	12·7	11 13 0
1876-90 ..	2,272,000	2,791,000	26,343,000	647,000	8,865,000	18·8	9 8 9
1891-05 ..	1,520,000	3,720,000	25,540,000	971,000	9,424,000	20·7	6 17 3
1906-10 ..	1,575,000	4,843,000	39,550,000	614,000	6,493,000	12·6	8 3 3
1911-14 ..	1,628,000	5,125,000	43,484,000	528,000	5,673,000	9·3	8 9 8
1915-17 ..	1,766,000	4,669,000	71,275,000	579,000	11,783,000	11·0	15 5 3

There was a great fall in the price of wheat during the latter half of the nineteenth century, brought about by the development of new wheat lands abroad, and the remarkable reduction in the cost of sea-borne transport. An average level of about 50*s.* a quarter was maintained over long periods up to 1874, and then for ten years the average was about 45*s.* After this the price fell rapidly until in 1894 a minimum of 22*s.* 10*d.* was reached. For about ten years prices ruled low, and then there was a recovery, and the average price in 1909 was 36*s.* 11*d.* In 1910-11 the price fell to 30*s.* 11*d.*, and in 1913 the average price was 32*s.* 4*d.* After the outbreak of war, owing to the difficulties of transport, there was an enormous rise in prices. In 1873, 3,700,000 acres were devoted to wheat in the United Kingdom, but with the fall in prices land rapidly went out of cultivation, and in 1904 the acreage sown was only 1,400,000, the lowest level reached. For the five pre-war years the average area under wheat was about 1,900,000 acres; during the war the wheat acreage was largely extended under the stimulus

of the Corn Production Act, until in 1918 the acreage was 2,800,000. Agriculture is one of the most essential industries, as the permanent material prosperity of a nation depends largely on the full development of the agricultural resources of the country. Unfortunately farming in this country did not prosper during the period when large and cheap supplies of corn, meat, and dairy produce were imported from abroad, with the result that between 1871 and 1913 the area under arable cultivation in Great Britain was reduced by 4,000,000 acres, or by more than one-fourth, and a large proportion of the rural population either emigrated or moved into already congested industrial centres in search of employment.

The average consumption of wheat (imported flour expressed in its equivalent weight in grain) in the United Kingdom for the five years 1909–13 was 7,500,000 tons, of which 20 per cent. was produced in the country, and the balance imported. The sources of our wheat supplies are varied, but those countries which send substantial and regular contributions are few.

The shares of the principal countries from which the United Kingdom draws supplies of wheat are shown in the following table; flour, expressed in its equivalent weight in grain, is included:

	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918
nada ..	13·1	16·4	17·2	17·1	16·9	21·9	22·5	29·7	23·5	23·7	21·3	25·1
stralia ..	7·4	5·3	9·2	11·5	13·0	10·4	8·7	10·5	0·1	3·7	10·5	4·6
lia ..	15·8	2·7	12·9	15·1	18·0	20·5	15·3	9·1	13·7	4·9	2·5	0·8
al from British mpire ..	36·4	24·5	40·0	44·1	48·5	53·1	46·5	50·6	37·5	32·6	34·6	30·6
ted States ..	28·8	36·3	22·2	15·2	17·9	20·9	34·8	35·3	47·2	63·0	58·7	52·3
entina ..	19·0	29·2	17·8	12·8	13·3	15·3	12·3	5·6	12·0	4·0	6·1	15·5
sia ..	9·9	4·7	15·8	24·3	16·2	7·3	4·1	6·3	0·8	—	0·1	—
l from Foreign untries ..	63·6	75·5	60·0	55·9	51·5	46·9	53·5	49·4	62·5	67·4	65·4	69·4

The outstanding feature of the trade during the war was the great increase in the imports from the United States.

The imports of wheaten flour since 1909, with the principal sources of supply, have been as follows:

	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
From British Empire ..	129,200	160,000	188,100	235,500	225,400	173,800	168,500	236,800	290,400	366,3[illegible]
Foreign countries	423,300	338,000	315,100	273,900	372,900	329,100	355,000	261,100	426,500	951,6[illegible]
Total	552,500	498,000	503,200	509,400	598,300	502,900	523,500	497,900	716,900	1,317,9[illegible]
From Canada	103,000	139,200	163,400	200,200	208,400	161,300	168,000	211,300	197,700	278,[illegible]
Australia ..	26,100	20,400	22,200	34,500	17,500	12,400	100	25,000	92,500	84[illegible]
France ..	26,700	21,900	20,000	18,500	15,000	18,200	3,200	—		—
Germany ..	29,300	29,400	14,100	18,500	22,800	10,800	–	–		—
Austria-Hungary	5,400	6,200	5,300	5,800	4,900	2,800	—	–	—	–
United States	346,400	251,400	250,800	201,100	307,800	277,900	337,000	259,100	402,100	98[illegible]
Argentina ..	4,200	5,000	4,400	5,000	9,500†	2,900	4,400	800	800	[illegible]
China ..	—	—	—	—	—	—	–	—	5,800	46[illegible]

The United States and Canada are the principal contributors, followed by Australia; before the war France and Germany sent fairly large quantities of flour. During the last ten years the milling industry in the United Kingdom has been greatly developed; the average quantity of wheat imported between 1896–1900 was 3,332,000 tons, whereas the average imports for the five years 1909–13 amounted to 5,166,000, an increase of 1,834,000 tons. The imports of flour fell, however, from an average of 1,055,000 tons in the earlier period to 532,000 tons in the later period. In 1917, owing to the question of freight, imports of flour were above the average of the ten preceding years, whilst in 1918, they were greatly in excess of the average for 1896–1900. At one time flour milling was carried on at the principal centres of production, but the great development in the sea-borne trade, and low freights, led to the

establishment of flour mills in many of the chief ports in this country, such as London, Liverpool, Hull, Glasgow and Leith, where most of the wheat is now dealt with. The average quantity of wheat milled in the United Kingdom during the five years 1909–13 was about 6,800,000 tons, which, on the basis of 70 per cent. of flour, would yield about 4,800,000 tons of flour, 900,000 tons of bran, and about the same quantity of offals. The development of the milling industry is a most satisfactory feature in the trade of the country, as not only does the industry provide employment for capital and labour, but the by-products produced in the country are of great value to the farmers. Unfortunately in pre-war years these by-products were extensively exported to Denmark and Germany. The export trade in flour is not of great importance: in 1913 it amounted to about 80,000 tons, valued at £856,000, the chief customers being Russia, Norway, the Canary Islands, Egypt and Malta. There is a considerable export trade in biscuits, worth £1,561,000 in 1913; in 1917 the value of this trade was £1,752,000 but the volume was 20 per cent. less than in 1913.

Canada. The rapid development of wheat-growing in Canada is reflected in the following statement.

Period	Acreage	Production
		Tons
1881–90	2,300,000	1,000,000
1901–10	5,900,000	2,950,000
1909–13	10,522,000	5,571,000
1914–17	13,771,000	7,379,000
1918	17,344,000	5,724,000

Though wheat is grown in nearly every province the great wheat belt is the western prairie, and the finest wheat region is the rich valley of the Saskatchewan, where the grain grows to perfection, and the yield averages over 26 bushels to the acre. On the prairie lands, which were first taken up, wheat is being grown year after year without rotation and without manure. In time this must lead

to soil exhaustion, but there are vast tracts of land still available, the land area of the three Prairie Provinces amounting to 446,000,000 acres. The further north wheat is grown, up to a certain limit, the better it is. The bulk of the prairie wheat is spring sown, and the chief dangers with which the farmer has to contend are hail in August and early autumn frost. The prevalence of smut is another draw-back, which lowers the yield and value of the grain.

The average exports of wheat and flour for the five years 1909–13 were 2,580,000 tons of grain, and for the four years 1914–17, 4,712,000 tons. The United Kingdom takes nearly the whole of the grain, and about two-thirds of the flour exports. In 1913 the exports of grain amounted to 2,100,000 tons, and of flour to 350,000 tons; the corresponding figures for 1916 were 3,800,000 tons of grain and 435,000 tons of flour. Canada also supplies British South Africa, the West Indies, Denmark and Norway with flour.

Australia. Wheat is the most important farm crop in Australia; approximately half the cultivated area is under wheat. The area under wheat is, however, small relatively to the area suitable and available for the cultivation of this crop. The question of the available land and the limits of profitable cultivation was closely studied after the outbreak of war, and it has been estimated that the present average production of 103,000,000 bushels in the four principal producing States, New South Wales, Victoria, South Australia, and Western Australia, could be increased five-fold. In addition Queensland has large areas which will undoubtedly be cultivated in wheat as the country develops. The average yield of wheat per acre in Australia is low, in New South Wales the average is under 11 bushels, and in South Australia, where the crop frequently fails to mature, the average yield is only 8 bushels. With such small returns wheat only pays in Australia because of the low cost of production. Actual figures of the cost of growing wheat on large farms in districts of less than 20 inches mean annual rainfall have shown that the crop can be sown and harvested for from 21*s.* to 23*s.* per acre, yielding 12 bushels. The quality of the wheats grown in Australia is not equal to the hard Canadian wheats, but the grain is of even grade, and has good milling qualities.

The following statement shows the progress made in wheat cultivation in Australia:

Period	Acres under wheat	Production
		Tons
1860-1	182,000	70,000
1881-90	3,200,000	720,000
1908-09 to 1912-13	6,791,000	2,241,000
1913-14 to 1916-17	10,727,000	3,129,000

In 1916-17 the production was 4,139,000 tons. The average quantity exported during the five pre-war years was 1,345,000 tons. During the war large stocks of wheat accumulated in Australia as shipping was not available for its transport. In normal times the United Kingdom takes over 70 per cent. of the total exports of grain, and about 15 per cent. of the flour. Australia supplies flour to South Africa, Portuguese East Africa, the Straits Settlements and the Philippine Islands. In 1913 it was estimated that 37,000,000 bushels, or about 1,000,000 tons of wheat, were milled in Australia.

India. Wheat is grown in all the provinces of India, but principally in the north-western part of the Indo-Gangetic plain, and in the Central Provinces, Central India and Bombay. About 35 per cent. of the total area is under irrigation either in whole or in part.

The area under wheat, and the production since 1891, are shown in the following table:

Period	Average area under wheat	Average production
		Tons
1891-1900	25,200,000	6,200,000
1905-09	28,000,000	8,500,000
1909-13	29,200,000	9,570,000
1914-17	31,070,000	9,440,000
1918	35,470,000	10,330,000

In recent years the extension of irrigation in the Punjab has brought into cultivation large areas of land. The large increase in the cultivation in 1918 was due, however, to the substitution of wheat for other crops. In Upper Burma, especially in the Shan States, land suitable for wheat is available, and will be cultivated when communications are improved and settlers attracted to the land. There is no immediate prospect of largely extending the wheat area in the principal wheat districts of India, where most of the land is cultivated, except by substituting wheat for other crops; the production can, however, be increased by improved methods of cultivation and by employing improved strains of wheat. The introduction on a large scale of the improved Pusa wheats, which are rust-resisting, and give a greater yield than some of those at present grown, will, in time, increase the production. Wheat and barley are often grown together, and consequently the wheat shipments frequently carry a percentage of barley. Under the terms of the Indian wheat contract of 1907, the admixture of barley was limited to 2 per cent. In recent years a great improvement has been made in shipping grain free from dirt, but the 2 per cent. allowance of barley is sometimes exceeded. Soft wheats are largely grown in India for export; for local consumption hard wheats are preferred. In the drier districts the durum varieties are cultivated, and a few hard winter wheats are to be found in the North. The substitution of superior types of wheat for the soft wheats now grown would not only meet the local demand, but also the requirements of the export trade. The exports of wheat from India, which average less than 15 per cent. of the total production, are influenced by the yield of other food crops, and in times of scarcity the exports fall away. Owing to the failure of the monsoon rains in 1918, wheat is being imported into India from Australia.

Between 1909-13 the exports of wheat and flour averaged 1,349,000 tons of grain. The United Kingdom was the best market for the grain; Continental countries also drew supplies from India. In 1913-14, 80,000 tons of flour were exported, principally to Eastern countries. The flour-milling industry in India is making good progress, but the bulk of the wheat consumed locally is converted

into flour in the primitive native mills, and the flour extraction is much greater than is customary in Western countries. The consumption of wheaten flour in India is increasing.

Mesopotamia. This country is one of great promise for cereal production. Before the war wheat and barley grown in Mesopotamia were shipped from Basra. The volume of the trade was not large, and it was carried on under great difficulties. Plans had been prepared for constructing important irrigation works which would have brought large areas of land into cultivation. Under Turkish rule, however, little progress had been made in carrying out these works, and the exactions of the local officials gave little encouragement to the Arab cultivators to extend their holdings. Since the war, under British administration, large areas have already been brought into cultivation by the extension of irrigation canals, and under a just rule cultivators are now able to enjoy the fruits of their labour. Communications by road and river have been improved, and Basra, transformed into an up-to-date port, promises in the near future to be an important centre of the cereal trade; its position in regard to India is of some importance, as the surplus crops of Mesopotamia will be a safeguard for India when the monsoon rains fail in that country.

British East Africa. During recent years the cultivation of wheat has been taken up by farmers with considerable success. The Nasin Gishu Plateau, covering an extensive area at an altitude of from 6,000 to 7,000 feet, is an excellent wheat country as regards both yield and quality; the country is flat and free from timber, and offers every facility for growing wheat on a large scale. Proximity to the railway is one of the important factors in growing wheat for export, but with improved communications there should be an outlet for the surplus produce of the country. Rust has proved troublesome, but as the result of experiments, rust-resisting varieties of seed are being found, and it should be possible for this country to produce wheat on a large scale.

Northern Africa. More than four-fifths of the total area cultivated in Egypt is capable of growing wheat, but so long as cotton remains the highly remunerative crop it is, there is very

little chance of extending wheat cultivation. During 1915 and 1916, owing to restrictions in the cultivation of cotton, the wheat area was extended and there was a surplus of grain for export. Under normal conditions, however, Egypt does not grow enough cereals for her own requirements.

Algeria and Tunis produce at present about 1,200,000 tons of wheat, of which Algeria exports about 150,000 tons. Hard durum wheats are largely grown by the natives, and the yield per acre is very low. The French colonists in Algeria, who cultivate the ordinary French varieties of wheat, obtain very good returns.

Wheat and barley are extensively grown in Morocco, and before the war the wheat exports averaged about 30,000 tons. With the improvement in the position of the natives under a better government, more land will come under cultivation, and by the provision of roads and railways opening up new districts, and reducing the cost of transport to the ports, there should be a great advance in the export trade. There are numerous flour mills in Morocco, and also factories for making Italian pastes, for which the hard Moorish wheat is very suitable.

Russia. Before the war wheat cultivation in Russia was making great progress, especially in Little Russia, and the regions of the Middle and Lower Volga, where the finest qualities of wheat are grown. In the Caucasus, Turkestan and Western Siberia the wheat areas were also being extended. Wheat exports had been advancing, and for the five pre-war years amounted on an average to nearly 4,500,000 tons a year. The quantity exported varied greatly from year to year : in 1908 it was as low as 1,500,000 tons, and in 1910 it was over 6,000,000 tons. Siberia has hitherto been little developed as a wheat-growing country; in Eastern Siberia rye is grown, and forms the chief food of the people. This country, with the neighbouring Chinese Province of Manchuria, contains vast tracts of land suitable for wheat. Owing to the upheaval in Russia and the utter disorganization of all means of transport, it cannot be expected that exports of cereals on a large scale will be renewed, even for some time after peace has been restored.

United States. At the present time the United States is the greatest wheat-producing country in the world. The estimated production of wheat in 1919 is 1,300,000,000 bushels, or about 34,800,000 tons, which represents more than one-fourth of the world's production of this cereal. The following statement shows the great advance made in the cultivation since the outbreak of the war:

Period	Average area	Average production	Average yield per acre
	Acres	*Bushels*	*Bushels*
1891–1900	43,100,000	559,000,000	13·0
1900–09	46,678,000	659,509,000	14·0
1909–13	47,068,000	685,259,000	14·5
1914–17	53,038,000	799,320,000	15·0
1918	58,852,000	917,000,000	15·5
Estimated 1919	..	1,300,000,000	

The Government encouraged farmers to grow wheat by various concessions and by fixing the price of wheat in advance of sowing; for the 1919 crops the farmer was guaranteed $2·20 per bushel, which compares favourably with the average farm price of 87 cents per bushel obtained between 1909 and 1913. Prior to the outbreak of war exports had been declining: the average exports for the five pre-war years were 2,900,000 tons, whereas between 1900 and 1902 they had averaged 5,790,000 tons. This decline was caused partly by the small annual increase in production, and also by the rapid increase in population, and by a considerable increase in per capita consumption. With increased production, and economy in consumption during the war, exports have rapidly advanced and averaged 5,576,000 tons between 1914–17. The exportable surplus for 1919 is estimated at from 350,000,000 to 400,000,000 bushels, or rather less than one-third of the estimated production. Various kinds of wheat are grown in the United States. The hard spring wheat, comprising about one-third of the total production, is grown principally in Minnesota and the two Dakotas, and is of fine quality, similar to the wheat produced in the Middle Volga region of Russia.

About two-thirds of the wheat is winter sown, and a very large proportion of this is raised in the Central Western States, of which Kansas is the most important. The wheats grown in the Pacific and Western Intermontane districts are generally soft and starchy. Much unimproved land suitable for wheat still remains, and the yield per acre, which is low, can be improved. The flour manufacture of the United States is of great magnitude, and the flour export trade much the largest in the world. Between 1903-07 the exports of flour averaged 1,335,000 tons ; before the war the average had fallen to about 1,000,000 tons, but during the war the average was nearly 1,500,000 tons. The United Kingdom is one of the principal customers for flour ; South American countries also draw their supplies largely from this source. During the war France and Italy had to indent extensively on the United States.

Argentina. Although at so early a date as 1585 wheat grown in La Plata was milled at the city of Cordoba, it was not until 1890 that Argentina ceased to import both wheat and flour. In recent years the production of wheat has increased to a remarkable extent, as the following statement will show :

Period	Area under wheat	Production	Exports
	Acres	*Tons*	*Tons*
1890–91	1,981,000	790,000	370,000
1899–1900 ..	8,027,000	2,587,000	1,804,000
1907–08 ..	14,227,000	4,900,000	3,400,000
1909–13	15,785,000	4,282,000	2,586,000
1914–17	17,864,000	5,900,000	

The principal type of wheat cultivated is the semi-hard red grain of Italian origin, which does not degenerate ; soft French and Russian varieties, and also hard durum wheats for the local manufacture of macaroni are also grown. In the colder southern regions a fine quality of hard winter wheat is now being cultivated. The principal wheat areas are in the provinces of Buenos Ayres, Cordoba, and Santa Fé, but it is probable that the wheat belt will

tend gradually more south, and that La Pampa will eventually become the chief source of supply. The breaking up of large estates has enabled the people to buy small farms, and has encouraged settlement on the land. The average yield of wheat per acre is small, as the crops are liable to damage from locusts and drought. With improved cultivation and abatement of the locust plague Argentina should be able to raise much larger crops. There are numerous flour mills in the country, and exports of flour have averaged about 120,000 tons, the bulk of which goes to Brazil.

Brazil. Wheat was formerly grown in the three most southern States, but the cultivation was abandoned because of the prevalence of rust. The advance in the material condition of the people of the country has resulted in a demand for wheaten bread in place of bread made from mandioca flour, and to meet this demand, flour and wheat have been largely imported from Argentina. For some years past the Government have given every assistance and encouragement to farmers to grow wheat, and good progress has been made in the southern States, where there are extensive areas of land suitable for wheat and also well provided with transport facilities. There appears to be every prospect that Brazil will be able to supply her own requirements in course of time, and also have an exportable surplus.

THE GROWTH OF THE SUGARCANE.*

BY

C. A. BARBER, C.I.E., Sc.D., F.L.S.

II

In the last article the growth of the sugarcane plant was traced from the planting of the seed or set to the stage when the actual canes appear above ground. This embraces the first of two well defined periods of growth. The second period covers the whole subsequent growth in the cane field and consists essentially of the lengthening and ripening of the crop of canes. To recapitulate, the manner in which the main stem gives off leaves, branches and roots was described, together with the way in which each of these branches develops. A complex mass of shoots is thus formed underground, each of which sends up its leaves above the surface, for the purpose of obtaining fresh supplies of food from the air while, at the bases of the leaves, it gives off series of ever thicker roots which penetrate the soil, and supply it with watery solutions of the salts needed for its further growth. In this growth, the parts, originally laid down in one plane, alter their relative positions according to their individual needs of space in the ground and in the air, and it was pointed out that many of them are crushed out of existence in the process. The roots and leaves develop much more rapidly than the stem bearing them, and, when the latter emerge from the ground, the leaves are already three to

* Reprinted from the *International Sugar Journal*, November, 1919.

four feet in length, and the plant is furnished with a mass of fibrous roots, penetrating deep into the soil. This, the first period of growth, is mainly subterranean, and lasts until the stems of different orders of branching begin to appear between the bases of the lower leaves. The main points to be kept in view, in this period, are the upward increase in the thickness of the stems, the protrusion of buds from the leaf axils and the increasing length and thickness of the new sets of roots formed on successive joints. The new leaves, meantime, become larger and broader at their base, soon completely encircle the joint till they overlap and enclose the younger parts in a set of enveloping sheaths. The length of successive joints also increases until all the growing parts are raised above the level of the ground.

The early stages of growth were traced both in cane seedlings and in plants grown from sets, and it will not be out of place here to refer to the reasons why the latter method of propagation is always adopted in sugarcane cultivation. While flowering is very common in the sugarcane, seedlings cannot be grown on an estate scale for several reasons. There are many kinds in which flowers are not found at all. In others, the flowers in the arrow are imperfect or, even when apparently perfect, turn out to be sterile. Again, when good seed is found in abundance, it is so small that planting from seed would be a very difficult and tiresome operation on a plantation. The time taken between sowing and reaping, as has already been pointed out, is much greater in the case of seed-sown plants than in those grown from cuttings. While a set will produce its bunch of canes in about 12 months, the plant produced from seed needs more like 16 to 18 months for it to reach maturity. As will be seen later, the canes in a bunch vary a good deal among themselves, but this is much more prominent in canes grown from seed. An even field cannot be expected from seed-grown canes. Lastly it is only within recent years that it has become generally known that good canes can be raised from seed, but, even if it had not been so, the vegetative method of planting would always have held, for the following reason. Plants produced from sets are exactly like their parents, and all the good and bad qualities of the variety are handed

down intact. The set is merely a piece of the parent plant cut off and given a prolonged existence. On the other hand, all seedlings differ from their parents. Sometimes these differences are so small that they are immaterial, and this is the case with cereals and other plants cultivated for their seeds; but, in the sugarcane, potato, apple, mango, orange, the variations are so great that a large number of worthless plants appear if seed is sown. Thus, besides the lateness of the crop grown from sugarcane seed, it would consist of a heterogeneous mass of canes differing in ripeness, sweetness, thickness, and every conceivable property. This subject has been introduced here because the writer has, not infrequently, been asked to send seeds of good cane varieties, raised on cane seedling experiment stations, for growth on a crop scale.

The second period of growth consists, primarily, of the elongation of the stems by the formation, in rapid succession, of much larger joints than those found underground, in other words, of the formation of canes. The two periods are much more pronounced in grasses or grain crops, and the growth in the second period is, in these cases, obviously for the purpose of lifting the flower into the air, so that pollination can be effected, and raising the fruit from the ground so that it can mature in the sun and be scattered abroad. The wild sugarcanes are still propagated by seed, and the habit has survived in the cultivated forms, although it is no longer necessary for them to be spread in this way. As we have noted, many cultivated canes still form flowers and seeds, and this formation closes the second period of growth. When the young canes are detected between the lower leaf-sheaths, they have already reached about normal thickness, and practically nothing is added afterwards in this direction. Further, no more branching or root formation is expected or desired. This is due, in the first place, to the absence of the forcing influence of the moist earth, and, in the second, to the repressive influence of light, at any rate on root formation. "Shooting" and "Rooting" therefore cease abruptly, and, although the buds and root-eyes continue to be formed in each joint as usual, they remain dormant or inactive. But it is because of their presence that it is possible to plant any cut piece of cane, with the

certainty that it will grow into a new plant. The moment darkness, together with moist earth, are present, both bud and root push their way out and commence growing.

Branching and rooting of the aerial portion of the cane plant are undesirable from many points of view, and it will be well to consider the matter in some detail. They weaken the plant, use up stored sugar and, by changing a further portion of it to the uncrystallizable form, decrease the richness of the juice. The canes of a healthy field crop should be as free as possible of lateral shoots and masses of roots, and, if these appear, we must adopt any means at hand to check their development. In many moist climates, where the rain collects in the bases of the older leaves, we find, on tearing them off, that the buds are shooting and the roots protruding. The usual remedy for this is to strip away the dying leaves at intervals. This "trashing" of the canes is regularly done in certain tracts, and might, perhaps, be extended elsewhere. In North Bengal, for instance, where trashing is unknown, it is easy, after stripping the canes at harvest, to mark the exact points in the formation of the cane, when the rains set in and when they ceased to flood the land. About half-way up the cane, the joints bear protruding buds and masses of crumpled roots, while these are not present above or below. It is accordingly suggested that, at the outburst of the monsoon, a thorough trashing should be tried, to see if this loss of energy can be prevented.

When canes fall down and lie on the ground, shoots and roots are not long in making their appearance on the joints of the fallen plant, owing to the comparative absence of light and the contact with the moist soil. The canes, in recovering their normal position, become curved and twisted, and the difficulty of reaping and handling are increased. Various means are adopted in different places to prevent this "lodging" of the canes, from earthing them up at the base to tying them roughly together. Probably the latter method reaches its greatest development in the Godavari district of the Madras Presidency, where abundant irrigation and rich soil, coupled with forcing heat, cause the canes to grow to an enormous height (Plate XVII, fig. 1). In one case a field was observed by the writer

in this locality, with an average height of twenty-five feet. As this part of India is liable to be visited by violent cyclonic storms during the growing season (Plate XVII, fig. 2) a series of " wrappings " have been introduced, and form an important part of the cane cultivation. Several of the older, but still firmly adhering, leaves of the cane are twisted to form a band, with which it is tied to its neighbours, while still quite small; and the whole field is treated in this way (Plate XVIII, figs. 1 and 2). In a well grown field as many as seven successive wrappings are done, and the last two or three are performed from the tops of immense three-legged stools; the operation costing a great deal then, because of its comparative slowness. But this is not all. The bunches of cane shoots thus brought together are fastened to upright bamboos sunk in the ground, and these are of three sizes. At first thin bamboos support the canes of a single bush; later on, larger and thicker ones bring several bushes together, and, lastly, tall, thick bamboos complete the work and unite several of the full grown clumps together. The bamboos, especially the large ones, last for several years and are carefully stacked at harvest time; but it will be readily understood that the practice, as a whole, is a very expensive one. The following notes were compiled at the Samalkota Sugar Cane Farm. The wrappings in a fairly good crop may be put down as costing Rs. 37-12-0 per acre. The bamboos, which are floated down the Godavari River in rafts from the hills, will cost Rs. 100 per acre in a freshly started plantation, and, after that, an annual charge of Rs. 26 should cover the cost of replacements. After three or four years, the old bamboos may be sold for odd fencing, etc., at from Rs. 6 to Rs. 8 per acre per annum. There is thus a recurring charge for bamboos of about Rs. 20 per acre per annum.

Shooting of the cane, often accompanied by rooting, is met with when there is any sudden check in growth. This check may be due to accidental injuries, the attack of insect pests or other causes, and, if arrows are formed, the upward growth of the cane ceases. In these cases, the roots and leaves still actively growing and sending up masses of formative material, the stream of nutriment is sufficient to force the buds to activity and they shoot out and form bunches of

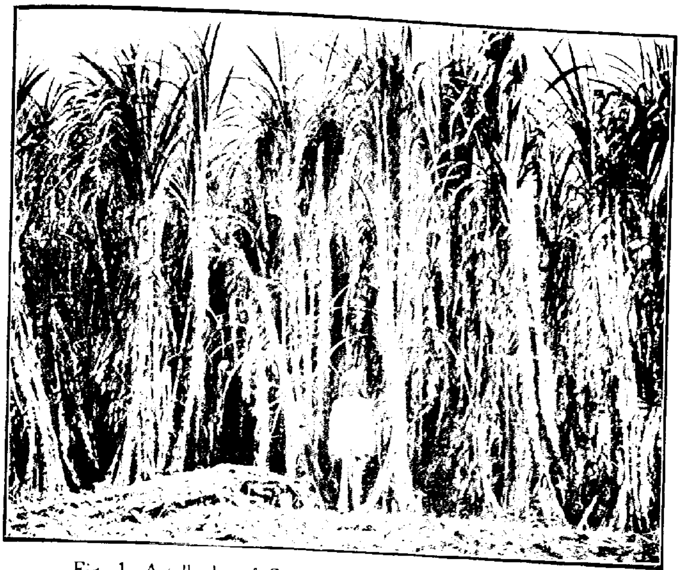

Fig. 1. A tall plot of Striped Mauritius Canes, 12 months old.
These produced 7 tons of jaggery to the acre.

Fig. 2. The effect of a Cyclonic Storm on an unwrapped field.

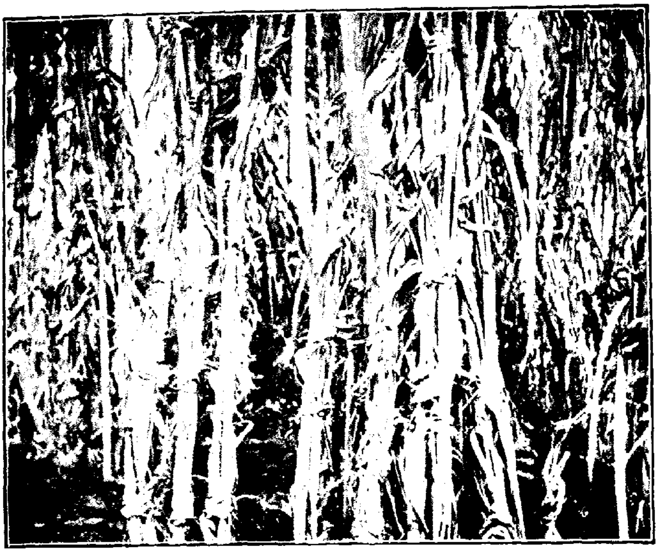

Fig. 1. Wrapped Cane, Samalkota Farm.

Fig. 2. Full stand of Red Mauritius Canes, 10 months old.

green leaves. As flowering often takes place before reaping, this is difficult to check. The cutting of the young arrows makes little or no difference, and the formation of seed is of far less detriment to the crop than the shooting of the buds. Many of the new seedlings flower profusely, which is not to be wondered at when we remember that they arise of necessity from freely flowering parents. But the matter should receive some attention, and, when possible, such new varieties should be introduced as have a minimum of this habit. When flowering commences, all growth in length ceases in the sugar-forming joints, and thus the weight of cane per acre is reduced; but it does not appear that flowering is of itself detrimental to the richness of the juice, because, as the results of many analyses, it has been found that at harvest canes that have arrowed frequently show a richer juice than those that have not.

When all is said and done, the best way in which to rid one's self of undesirable characteristics in plants is by the selection and growth of varieties which prove themselves to be free from them in the locality concerned. We have now reached the stage of fighting diseases in crops by indirect methods. The *sereh* in Java was mastered by abolishing ratoons, raising planting material in separate hill nurseries, but chiefly by the introduction of new kinds of cane; and most faults in the canes can be combated by a similar trial of new varieties, coupled with good cultivation and special attention to drainage—in other words, in giving the newly introduced canes every chance of normal, healthy growth. And the matters of shooting and rooting and the lodging which encourages them should be approached in the same manner. Some varieties shoot and root much more than others, and the extent to which they do so varies greatly in different places. Many new seedlings with excellent properties of yield and juice are liable to fall, and show this tendency more in some climates and soils. A cane which will stand erect in a stiff, clayey soil, will, for instance, fall all over the place in light alluvium; and this accounts for the extraordinary favour extended to *White Tanna* in the light soils of Bengal. The most interesting case met with by the writer was that of a seedling, raised in the Coimbatore sugarcane station, which produced a tufted bush of shoots with two or three long canes emerging therefrom.

These canes never rose from the ground, but crept along its surface. One of them was found winding in and out like a snake among the neighbouring seedlings, and, upon being extricated, measured twenty feet in length.

REPORT OF THE LINCOLN TRIALS.*

THE Report of the Tractor Trials held under the auspices of the Society of Motor Manufacturers and Traders, during the month of September 1919, is at last published. It is rather an imposing publication, perhaps it is fairer to say that in importance it compares well with the event which it concludes. I use the word "concludes" advisedly, since, as was widely advertised prior to the trials, they were not complete, nor was their purpose served in its entirety, until the observations of the interested spectators were supplemented by the advice of the experts who were appointed judges and technical advisers. Properly to have fulfilled its purpose, there can be no denying that it should have been issued within, at the most, a few weeks of the conclusion of the trials. However, this much can at least be said: the compilers have done their work well, and the Report is worth waiting for.

It is conveniently divided into four sections. The first part gives the regulations and conditions governing the trials; it is concluded by a map of the ground. The second portion gives the report of the technical adviser and includes a number of useful tables. The third part is also the work of the technical adviser; it embodies technical descriptions of each and every tractor, each description being accompanied by an illustration of the machine to which the text refers, as well as a reproduction of the chart which graphically shows the tractor's behaviour during the dynamometer test of its drawbar capacity. The fourth part contains the judges' report of the tractors and implements. There are, in addition, some supplementary illustrations, showing the types of dynamometer used, and the form of interchangeable rim used by the Garner tractor. The Report occupies in all just one hundred

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* Reproduced from *Country Life*, dated 17th January, 1920.

pages, of which it may be said that a single one omitted would have been missed.

TECHNICAL ADVISER'S THE LION'S SHARE.

The technical adviser, Mr. G. W. Watson, appears to have been responsible for the lion's share of the work. His Report is summarized under ten heads; (1) Drawbar dynamometer tests, (2) Ploughing resistance dynamometer tests, (3) Ploughing heavy land, (4) Ploughing cliff land, (5) Haulage tests, (6) Threshing tests, (7) Mechanical construction, (8) Safety of operation, (9) Results of test on oil, (10) Brief descriptions of each make and type of tractor engaged.

With the method of carrying out the dynamometer tests, I do not propose to deal. I described it at some length a short time ago. The important results are tabulated, in company with essential technical data regarding each tractor, in Table I, which also contains much useful information directly obtained as a result of the drawbar tests. Perhaps that column which will make the most direct appeal is the one in which the capital cost per 100 lb. of drawbar pull is given for each tractor. The actual horse power available at the drawbar, when the tractor is travelling at its normal speed, is calculated and tabulated, as is also a figure for the "efficiency of adhesion" of the machine. The last named is obtained by proportioning the drawbar pull to the weight of the tractor. Its value, as Mr. Watson points out, lies rather in the indication which it gives of the efficacy of the type of spud employed. No information, unfortunately, is vouchsafed as to the type of spuds actually used by each tractor during the trials, so that the information will be of direct use to the individual manufacturer only, although the user will, of course, reap the benefit ultimately.

PLOUGHING RESISTANCE.

It was a novel and sound idea to ascertain the ploughing resistance of every field in which trials were held. Mr. Watson states that it was his intention to go further than this, and test each individual type of plough, from which bold venture he was prevented

by the difficult transport conditions then prevailing. For strictly accurate results such tests are perhaps necessary. At the same time the labour involved would be considerable, as I doubt whether it would be sufficient to make comparative tests in one class of soil only, and to test each type of plough in each class of soil would be work for an army of technical advisers, even of such as Mr. Watson evidently is. The results of these tests are given, in conjunction with other data relating to the performances of the tractors in the fields concerned. That is to say, the ploughing resistance of the heavy land is tabulated with the figures which give the performance of the machine in that land (Table II), while those obtained from the light land are similarly collated with the data in connection with the work performed there. In the heavy land, the soil is, with two exceptions, classed as heavy clay, and the resistance, apart from the two exceptions named, varies from 10·90 lb. to 12·30 lb. per square inch of the sectional area of the furrows cut. That is to say, for a furrow 10 in. wide by 5 in. deep, the resistance would vary from fifty times 10·90 lb. to fifty times 12·30 lb., namely, 595 lb. to 615 lb. The difference in the nature of the soils worked on the second day of the trials is much greater than this. They vary from light loam through medium to heavy loam, and the ploughing resistance from 7·91 lb. to 11·40 lb. per square inch, so that a plough cutting a furrow 10 in. wide by 5 in. deep might call for an effort of anything between 395 lb. and 570 lb.

Other figures of interest in these two tables (II and VI) refer to the delays which occurred to the tractors during the day. The stoppages were remarkably few. Lengthy stops only occurred in connection with the ploughs. Mechanical troubles of any consequence occurred only in respect of two tractors, and apart from these the maximum time lost by any tractor was thirteen minutes.

ACRES PER HOUR.

Most of the important data have been separated from Tables II and VI, and are repeated in smaller tables, of which III, IV and V give the ploughing capacity of the tractors in acres per hour, the fuel cost per acre, and the fuel cost per hundred pounds of drawbar

pull respectively while operating in the heavy soil. Tables VII, VIII and IX give corresponding figures for the work performed in the light land. On account of their simplicity, I do not doubt that these tables will make the most direct appeal to the lay reader, particularly as the information which they give answers so aptly the questions which the farmer naturally asks when he is endeavouring to discover the type of tractor most suited to his needs. The figures will no doubt surprise many. In no case, for example, on the heavy land does any tractor accomplish the "even time" of tractor working ploughing "an acre an hour." The nearest approach is made by the Fiat, which turned over an average of 0·87 or nearly seven-eighths of an acre per hour. On the light land one tractor exceeded the average of an acre per hour. The tractor concerned was, however, the only steam-engined machine present. Of internal combustion engined machines the Fiat again showed to best advantage, accomplishing 0·93 acre per hour. Twenty-three out of thirty-four tractors averaged more than half an acre an hour on heavy land, and all but five of the thirty-seven which demonstrated on the light land exceeded that amount. The average of all the tractors on the heavy land was 0·578 acre per hour, and on the light land 0·653 acre per hour.

Fuel costs.

In regard to cost of fuel per acre most divergent results are recorded. Certain machines used petrol throughout, and therefore show to considerable disadvantage on the fuel account, even if they may have the advantage of the others in other directions. Apart from these, however, the difference between best and worst is almost 200 per cent. in excess of the former. On the heavy land, for instance, whereas the Blackstone Track-layer ploughed an acre at a cost of 3*s.* for fuel; and tops the list on that account, the Illinois used paraffin costing 8*s.* 11*d.* while doing the same work. It is only fair to point out that the latter machine was cutting soil a little stiffer than that which fell to the portion of the Blackstone, and was, moreover, ploughing to a depth of 6 in. as against the Blackstone's 5 in. An even greater discrepancy is observable between the

performance of the paraffin users on the light land. While the Fiat, which again heads the list, cuts an acre for 2*s*. 5*d*. the corresponding figure for the Pick is 8*s*. 4*d*. and in this case, although the Pick was cutting half an inch deeper than the Fiat, the soil which it was working was considerably lighter in texture than was the case with the least expensive worker. Some of the difference may be due to variation in plough draught, although there is no evidence either for or against this assumption. In any event, he would be a bold man who would assert that any one plough could be 200 per cent. more difficult to haul than the lightest draught implement made. The average cost of fuel per acre on the heavy land, considering paraffin-burning tractors only, was 5*s*. 1½*d*., and on the light land 4*s*. 2½*d*.

Fuel cost in relation to drawbar effort.

I was at first somewhat puzzled and I anticipate that many readers of the Report will be similarly at a loss to understand the object in publishing Tables V and IX, which give the cost per hundred pounds of drawbar pull per acre ploughed. After consideration I have come to the conclusion that the object is that of correcting the previous tables which give the cost per acre, in which tables the incidence of drawbar pull, or depth ploughed, is not taken into account. Thus in the heavy land the Blackstone Track-laying tractor costs least of any for fuel per acre ploughed, but when the pull exerted is taken into account it is beaten by the Clayton and the Overtime, both of which pulled four-furrow ploughs as against the Blackstone's three. However, since the soils worked by the three tractors were pretty much the same in all cases and the depth of ploughing the same too, it would appear that the smaller machine is really the more economical after all. The evidence, however, is not conclusive.

Hauling and threshing.

All the machines which demonstrated their ploughing capacity were not entered for the hauling and threshing. As a matter of fact, only eleven took part in the hauling test and thirteen in the

threshing trials. The results were generally satisfactory but figures showing the comparative performances of the tractors are not given for reasons which are explained in the Report. The outstanding lesson of the haulage test was the superiority of rubber tyres. Every machine fitted with rubber tyres made the ascent of the somewhat steep hill successfully. Of the steel-tyred tractors only the heavy weights, which the judges state are too heavy to be suitable for tillage operations, were able to perform satisfactorily. That the tractors all came through the threshing test without trouble only goes to confirm what I have pointed out in these columns, that given a tractor engine which is in good condition, and provided that the corn is fed judiciously, there is hardly a tractor on the market which is not capable of driving a full-sized thresher. It is when the machine has to be hauled from place to place that trouble commences, the standard types of thresher weighing five tons.

MECHANICAL CONSTRUCTION.

As regards the mechanical construction of the tractors, the Report is a favourable one. One or two exceptions to this general rule are mentioned, and the technical adviser's opinion as regards safety of operation is also favourable, except as regards two machines. No special results seem to have accrued from the tests of the used engine oil; whatever there are seem to be negative. Probably the truth is that the trials were not of sufficient length to affect the oil one way or the other.

DESCRIPTIONS: THE DYNAMOMETER CHARTS.

With the descriptions of the tractors we do not need to concern ourselves here. Each is followed by a brief specification of the machine, the data therein contained being largely the same as that which is tabulated in Table I, with additions. The dynamometer chart for each machine concludes each description.

JUDGES' REPORT.

The judges have been outspoken, but somewhat brief. Not a few manufacturers will find themselves disagreeing very strongly

with the opinions expressed, which in a way is as it should be. At the same time, there will be many, I anticipate, who will complain, with some show of justice, that the judges have not been sufficiently explicit. It hardly seems fair, for example, to say, as occurs in the Report of one machine, that "Its performance..........was not satisfactory," without amplifying the statement by indicating the direction wherein lay the fault. Reading through the Report, it becomes apparent that the authors are of the opinion that the limit of tractor weight for satisfactory use on the soil, except when the weather is particularly favourable, is 2 tons 10 cwts. With that opinion there will be few to disagree. On the other hand they appear to think that the heavier machines are well adapted for haulage on the road, and the farmer who wishes for a general purpose machine will have to decide for himself as to how far he can reconcile these conflicting conditions. Where a machine is considered as a hauling engine, the tendency appears to have been to condemn it if it is not properly equipped with a double set of brakes and springs. The judges, too, have set their faces against any tractor which, in preparation for threshing, has to be reversed into position; in several cases they state: "It is inconvenient to set in position on account of the fact that it must be placed with its rear wheels towards the thresher." They are equally intolerant of the tractor which has to be set transversely to the belt drive.

THE REPORT.

The Report is available to the general public, and I am asked to state that all enquiries concerning it should be addressed to the Tractor Trial Organizer, the Society of Motor Manufacturers and Traders, Limited, 83, Pall Mall, London, S. W. 1. Its price is 3*s.* post free and remittances must accompany orders.

Notes

MOTOR TRACTOR TRIALS AT NAGPUR.

A VERY interesting "meet" was held at Nagpur during the week beginning on the 16th February, 1920, for the purpose of testing motor tractors. Of the tractors which were expected to compete only five were present. These were as follows :—

	Rated B. H. P.	Weight
F. I. A. T.	25	6,000 lb.
Lauson	25	6,500 ,,
Austin	25	2,900 ,,
Fordson	22	2,600 ,,
Cleveland	21	3,000 ,,

Though the numbers were few yet the interest of these trials lies in the fact that it is the first time that tractors have been tried in black cotton soil. These black cotton soils dry and crack very deeply and, when cultivated, turn up in big concrete-like blocks. Under these conditions a light machine, travelling partly on the land and partly in the furrow, is completely at sea, however useful such light machines have proved themselves in other parts of India.

The F. I. A. T. with a drawbar adjustment, which enables the tractor to work on the land while having sufficient power and weight to stand the consequent side pull, was quite capable of tackling any class of land put before it.

Neither the drivers nor the implements were up to the standard of the tractors. The former obviously lacked the experience which will come with time. In some cases drivers did not lift their ploughs at the headlands and thus put a strain on the plough beams which no implement is designed to stand.

The implements were all of the self-lift type. Riding ploughs would have made much better work, the extra man involved is of little moment compared to the resulting advantages.

None of the tractors had any mechanical trouble during the week in spite of the severe strain involved, and this is a good proof of the standard of mechanical perfection to which tractors have now attained.

The Agricultural Department of the Central Provinces is to be congratulated on the success of the demonstration. Messrs. Clouston, Allen, Plymen and the other members of the staff, along with the numerous visitors who were enrolled as judges and observers, had a very arduous week.

It is obvious, however, that with some 50–60 makes of tractors presently on the market, trials of a more extensive nature are required. Trials for all India are needed, and from the data provided by them, the various provinces will be able to select according to their special requirements. [G. S. HENDERSON.]

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CATTLE SALE AND DEMONSTRATION AT PUSA.

A PUBLIC AUCTION of surplus cattle from the pedigree dairy herd was held at Pusa on the 17th March, 1920. These sales, first started in 1917, have created a considerable amount of interest and have undoubtedly focussed public attention on the possibilities of dairy cattle breeding in India. The cattle were brought forward in excellent bloom considering the character of the season, and the following prices were obtained.

		Rs.	A.	P.
Montgomery bull-calves	14	1,525	0	0
Cross bred bull-calves, Montgomery cow × Ayrshire bull	15	705	0	0
Montgomery cows	6	1,260	0	0
TOTAL ..	35	3,490	0	0

The next sale will be held in November and, among other stock, over 20 cows are expected to be exposed.

On the morning preceding the sale a demonstration on tractor implements was held. Both sale and demonstration were well

attended. A representative gathering of planters was present and general opinion testified to the enormous importance that the tractor movement foreshadows to India. [G. S. HENDERSON.]

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THE USE OF SOME SALT WATER PLANTS AS FODDER.

THERE are a number of plants the use of which as fodder is well known to the cultivators in one tract, but is altogether unknown in another. This may be due to the fact that good nutritious fodder may be scarce in the first and ample in the other. The poverty of the agricultural areas in the Ratnagiri district has taught its people to put to use every bit of available land for agricultural purposes, and when it is not possible to make such use of it, an attempt is made to employ such plants as may be naturally growing on poor land for some economic purpose. In that district fodder-growing areas are poor and limited. The cultivators therefore have to fall back upon such plants as can naturally grow on the poorest of soil and can take care of themselves. In the tidal rivers and creeks along the west coast also, there are immense areas which are naturally covered with several kinds of mangroves, and with grasses and holly-like shrubs. The people of the Ratnagiri district have learnt long ago the use of these plants as fodder. These plants grow in salt water and naturally contain a considerable quantity of salt. They are, nevertheless, fed, even in normal years, as green fodder to milch cattle and if possible to work animals also.

The holly-like *Marandi* (*Acanthus ilicifolius*) is a spiny plant about three to four feet in height. It is erect and unbranched. Its leaves resemble those of holly (*Ilex*) from which it derives its specific name. The plant is generally cut before it flowers and chopped up into small bits of three inches long. They are then beaten with a strong rod so that all the spines are completely broken down. This is the only precaution that is to be taken in preparing the stuff for feeding. For one animal a man can prepare the stuff, ready for feeding, in half an hour. In the beginning a small quantity of *bhusa* or cotton seed or any other similar food may be added to the feed before giving it to cattle. About twelve to fifteen

pounds per day can be given to an animal which begins to like it in about a couple of days. When the animal is accustomed to it, the *bhusa* and cotton seed may be dispensed with. The spiny nature of the plant need not deter one from using it; the spines are not at all dangerous as in the case of the prickly pear; even young boys can be readily trained to prepare fodder from it.

The *tivir* (*Avicennia officinalis*) is a large spineless shrub and covers large areas in the creeks. This plant can be readily distinguished from other mangroves by its peculiar roots which project in large numbers above the surface of the mud. Branches of this plant may be cut and fed to cattle.

The *lavi* (*Æluropus villosus*) is a small grass about twelve to fifteen inches long and grows in salt water mud. This is simply pulled out of the mud with its roots. It is first washed in salt water so as to remove the greater part of its mud and again in fresh water to remove every trace of mud. It is immediately fed to cattle—preferably to milch cattle. About ten to fifteen pounds is given to every animal. There is however a limited quantity of this grass available in the tidal creeks.

The first two plants are very common in all the creeks and rivers of the west coast of India. They are apparently never utilized by cattle owners of the Kolaba, Thana and Surat districts. They are strongly recommended to use these plants as long as they are available and thus increase the supply of fodder. [H. P. PARANJPYE.]

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EXPERIMENTS WITH PEANUTS IN MESOPOTAMIA.

AN interesting account of a successful experiment which has been carried out at Fellujah, on the river Euphrates, about thirty-eight miles west of Baghdad, with peanuts (or groundnuts) has been furnished by the United States Consul at Baghdad. One of the most remarkable facts about Mesopotamian agriculture is the scarcity of oil-seeds among the crops grown in the country. Practically no oil-seeds are grown, with the exception of a little sesamum and linseed. In other oriental countries oil-seeds are quite commercial crops. India, for instance, has its linseed, cotton-seed, coconut, gingelly,

rape-seed, sesamum and peanuts, while Egypt has its cotton and sesamum and China its soy-beans. Considerable interest, therefore, is attached to an experiment with peanuts carried out at the Fellujah gardens. The plot was only a small one, about one-tenth of an acre being sown. The crop was sown in June and lifted in November. The person in charge of the garden had no experience of this crop, and sowed somewhat too thickly and overwatered, yet the crop, when first lifted, gave 2,550 lb. of nuts, which, when dried, gave 1,800 lb. per acre. Peanuts are already in considerable demand in the country, large quantities being imported from India. At present the nut is consumed in a parched state or is used for making sweetmeats. Later on, when the production exceeds this local demand, the surplus will find a ready export as an oil-seed. The variety grown at Fellujah is a tight-husked variety, with a very attractive bright-red skin, known as the small Japanese. It was not known in Mesopotamia before, and local merchants who have seen samples have been much interested. It has the advantage of being quick growing, requiring comparatively little water, and being easy to dig. Demonstration plots at various centres were to be arranged for this year by the Agricultural Department, and it should be possible to establish this crop on a commercial scale in a short time. [*Journal of the Royal Society of Arts*, dated Feb. 6, 1920.]

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

WOODHOUSE-SOUTHERN MEMORIAL FUND.

THIS fund is now closed. The total amount of the fund is Rs. 2,578-4-0 (including Rs. 24-2-0 interest allowed by the Bank and deducting Rs. 7-14 discount on cheques). Rs. 317 was specially contributed by subscribers for the memorial to Mr. Southern and Rs. 180 for that to Mr. Woodhouse. The final allotment, therefore, is :—

		Rs.	As.	P.
Woodhouse Memorial	.. ..	1,220	10	0
Southern Memorial	.. ..	1,357	10	0

It is proposed to send Rs. 1,200 to the Government of Bihar and Orissa and Rs. 1,300 to the Government of the Punjab for the purpose of endowing a Memorial Prize in the Provincial Agricultural College. The balance of Rs. 78-4 will be expended on enlarged photographs of the deceased officers to be hung in the Council Room of the Agricultural Research Institute at Pusa.

J. MACKENNA,

23rd March, 1920. *Agricultural Adviser to the Government of India.*

THE HON'BLE SIR CLAUDE HAMILTON ARCHER HILL, K.C.S.I., C.I.E., has resigned his office as an Ordinary Member of the Council of the Governor General of India, in charge of the Department of Revenue and Agriculture, with effect from the 11th April, 1920.

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THE HON'BLE SIR THOMAS HENRY HOLLAND, K.C.S.I., K.C.I.E., has been appointed to be a Temporary Member of the Council of the Governor General of India in the vacancy caused by the resignation of the Hon'ble Sir Claude Hamilton Archer Hill, K.C.S.I., C.I.E.

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THE HON'BLE MR. R. A. MANT, C.S.I., I.C.S., Secretary to the Government of India in the Department of Revenue and Agriculture, has been granted privilege leave for three months with effect from the 27th March, 1920. He reverts to the Punjab on the expiry of the leave.

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MR. J. HULLAH, I.C.S., has been appointed to officiate as Secretary to the Government of India in the Department of Revenue and Agriculture, with effect from the 27th March, 1920.

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THE services of MR. J. MACKENNA, M.A., C.I.E., I.C.S., Agricultural Adviser to the Government of India and Director of the Agricultural Research Institute, Pusa, are replaced at the disposal of the Government of Burma, with effect from the afternoon of the 30th April, 1920.

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MR. F. M. HOWLETT, B.A., F.E.S., Imperial Pathological Entomologist, is appointed to the charge of the office of the Forest Zoologist at the Forest Research Institute and College, Dehra Dun, in addition to his own duties, with effect from the 7th February, 1920.

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MR. C. M. HUTCHINSON, B.A., M.A.E.B., Imperial Agricultural Bacteriologist, has been granted combined leave for eighteen months, with effect from the 10th April, 1920.

MR. J. H. WALTON, B.A., B.Sc., Assistant Agricultural Bacteriologist, has been appointed to officiate as Imperial Agricultural Bacteriologist during the absence of Mr. Hutchinson on leave.

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DR. W. H. HARRISON, D.Sc., Imperial Agricultural Chemist, has been granted combined leave for eighteen months with effect from the 15th April, 1920, or any subsequent date from which he may avail himself of it.

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WE offer our hearty congratulations to Mr. H. E. Annett, Agricultural Chemist, Bengal, who has been awarded the degree of D.Sc. by London University in recognition of his work of alkaloids.

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COLONEL A. SMITH, F.R.C.V.S., Principal, Bengal Veterinary College, has been granted combined leave for six months from the 25th March, 1920.

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MR. P. J. KERR, M.R.C.V.S., I.C.V.D., Superintendent, Civil Veterinary Department, Bengal, on return from leave, is appointed temporarily, with effect from the 26th March, 1920, to the post of Second Imperial Officer, Bengal Veterinary College, and to act as Principal of that College during the absence, on leave, of Colonel A. Smith.

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MR. D. QUINLAN, Superintendent, Civil Veterinary Department, Bihar and Orissa, was on privilege leave for a fortnight with effect from the 25th February, 1920.

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MR. P. B. RILEY, M.R.C.V.S., has been appointed to the Indian Civil Veterinary Department, with effect from the 21st March, 1920, and has been posted to Bihar and Orissa as Second Superintendent, Civil Veterinary Department.

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COLONEL J. FARMER, C.I.E., F.R.C.V.S., Chief Superintendent, Civil Veterinary Department, Punjab, has been granted

combined leave for eight months with effect from the 20th February, 1920.

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MR. T. F. QUIRKE, M.R.C.V.S., has been confirmed in the Indian Civil Veterinary Department, with effect from the 8th February, 1920, and has been placed on special duty in the office of the Chief Superintendent, Civil Veterinary Department, Punjab.

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THE University of Bombay has conferred the degree of M.AG. on Mr. G. S. Kulkarni, Acting Assistant Professor of Mycology, Agricultural College, Poona.

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THE HON'BLE DIWAN BAHADUR L. D. SWAMIKANNU PILLAI, Avargal, I.S.O., is appointed to act as Director of Agriculture, Madras.

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MR. R. CECIL WOOD, M.A., from date of relief of his appointment as acting Director of Agriculture, is appointed to act as Deputy Director of Agriculture, Livestock, Madras.

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RAI BAHADUR K. RANGA ACHARYAR, Avargal, Government Lecturing and Systematic Botanist, Coimbatore, has been on privilege leave for two months from the 22nd March, 1920.

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MR. G. EVANS, C.I.E., M.A., Deputy Director of Agriculture, Central Provinces, has been granted an extension of leave for two months.

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MR. C. W. WILSON, M.R.C.V.S., Superintendent, Civil Veterinary Department, Central Provinces, has been granted combined leave for eight months from the 19th March, 1920.

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MR. W. N. HARVEY, Deputy Director of Agriculture, Northern-Eastern Circle, Gorakhpur, has been granted combined leave for

eight months and eight days with effect from the 15th March, 1920.

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MR. A. McCRACKEN, I.C.S., Burma, has been appointed Assistant Rice Commissioner, Rangoon, from the 12th February, 1920.

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CAPTAIN T. D. STOCK, who has been appointed by His Majesty's Secretary of State for India to the Indian Agricultural Service and who has been posted to Burma to fill the post of Economic Botanist in the local Department of Agriculture, reported his arrival at Rangoon on the forenoon of the 24th December, 1919.

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MR. D. F. CHALMERS, I.C.S., Director of Agriculture, Burma, has been granted privilege leave for six months with effect from the date on which he may avail himself of it.

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MR. C. R. P. COOPER, I.C.S., Officiating Registrar, Co-operative Societies Department, Burma, is placed in charge of the Office of Director of Agriculture, Burma, in addition to his own duties, in place of Mr. D. F. Chalmers proceeding on leave.

Reviews

Les Amendas et l' Huile de Palme (Palm Kernels and Palm Oil).—By E. BAILLAUD and A. STIELTJES. Institut Colonial de Marseille; 1920.

THIS volume is chiefly an analysis of the evidence given before the British Committee on Edible and Oil-producing Nuts and Seeds, which reported to Parliament in June 1916. It contains much that is of interest to India, especially in view of the discussion on the conservation of oil-cakes in the country which took place at the recent meeting of the Board of Agriculture at Pusa.

The oil-producing nut and seed industry is one which was greatly influenced by the war, and the authors consider that England alone of the countries engaged has been able to profit by developing its market for edible oils. The major part of this development has been concerned with the African oil palm, *Elaeis*, but coconut and other oil-producers, such as groundnut, sesamum, etc., have also shared. Great Britain has, in fact, not only captured a great part of the trade in oil palm products formerly centered in Hamburg, but has also encroached extensively on the hitherto undisputed supremacy of Marseilles in the other edible oils.

It is pointed out that, before the war, Germany, having a people who consume edible oils largely under normal (pre-war) conditions, concentrated on the crushing of products such as *Elaeis* kernels and copra which give a high yield of oil, while in England, edible oils being in relatively small demand, the seeds such as linseed giving the best cakes and industrial oils were most dealt in. This initial advantage in the edible oil industry was developed by the Germans by means of protective duties which enabled the German manufacturer to obtain a higher price for his oil in Germany than

that at which he could export it, by subsidies to shipping companies and probably (though absolute proof of this is not advanced) to the manufacturers, and by low rates of transport to factories in the interior of the country. It is believed that the Germans could sell their oils in Germany at £ 2 a ton more than English manufacturers could get in England. The German machinery was also more efficient than that used in England which left considerably more oil in the cake. The net result was that Germany sent annually about 50,000 tons of palm kernel oil to England in the years just preceding the war and a further considerable quantity reached England in the form of margarine through the intermediary of Dutch houses. On the other hand it was impossible for other countries to sell oil or margarine in Germany at a profit on account of the heavy duties on these products, while the raw material was allowed to enter free.

The war put an end to this. The result was an enormous development of the edible oil industry in Great Britain. In February 1919, the production of margarine in England was 8,000 tons a week as against 1,500 tons in 1913, and was approximately sufficient to meet the British demand. The total production of vegetable oils reached 331,808 tons in 1917 and 380,270 tons in 1918. Almost all classes of oil-producing nuts and seeds shared in this increase: the importation of groundnuts rose from 15,000 tons in 1913 to 137,750 tons in 1917; of copra from 14,000 to 50,400 tons, and of palm kernels from 36,000 to 249,000 tons (equalling the pre-war German figure) in the same period. This occurred without any special Government action other than the encouragement by the Food Controller of importation by private agency, and the control of the margarine factories so as to secure the application of uniform formulae. Maximum prices were fixed for the latter. Arrangements were made for the imposition of an export tax of £ 2 per ton in British colonies on oil palm products to foreign countries but no action on this was taken during the war (though steps have recently been taken to enforce it).

In France, Government acquired the whole output of its colonies and prohibited importation from other sources. The

result was disastrous. When groundnuts were selling in England at 74 francs per 100 kilos, palm kernels at 63 francs and copra at 87 francs, French manufacturers had to pay 126, 142 and 215 francs respectively. Against a normal importation of 256,000 tons of undecorticated groundnuts, 237,000 tons of decorticated groundnuts and 112,000 tons of copra, France could only get in 1918, 73,000, 9,000 and 21,000 tons respectively, plus 40,000 tons of palm kernels and 14,000 tons of palm oil. Even by paying twice the price prevailing in England, factories could not obtain anything like their requirements: many had to close, while England was building up a new industry.

Furthermore, beyond a first effort in 1916, nothing was done in France to popularize the use of oil palm cake, which was scarcely known previously. The result is that at present it fetches less than half the price of coconut cake. Yet intrinsically it is scarcely inferior to the latter and in Germany was actually preferred before the war for feeding milch cattle, giving, it was claimed, a slight increase in fats in the milk. In England efforts were made by the Board of Agriculture, Experiment Stations and Agricultural Colleges to advocate its use, and there was an ample supply available at relatively low prices when other feeding stuffs were scarce. It is now getting a price which is in relation with its intrinsic value and is in the neighbourhood of coconut cake though of course inferior to that of linseed.

It is not to be wondered at, therefore, that as soon as the importation of copra again became feasible, the French industry abandoned the use of oil palm kernels, and in the spring of 1919 sent about 80,000 tons of the latter to Germany out of their stocks of about 100,000 tons.

Another circumstance tending to aggravate the situation in France, in view of the fact that the French colonies cannot at present supply more than one-fifth of the French demand, is the growth of the oil crushing industry in the eastern tropics during the later stages of the war. This growth is especially noticeable in India, the Dutch Indies and the Philippines. No less than 53 oil crushing factories have been recently started in the Dutch colonies,

42 of which are in Java. These have a capacity of some 250,000 tons of copra annually. In the Philippines also the export of coconut oil has grown from 13,500 tons in 1915 to 115,280 tons in 1918 while copra has fallen in the same time from 82,000 to 55,000 tons.

All this, the authors think, will make it most difficult to revive the French industry behind tariff walls. They consider that the proper course to take is to stimulate production in such commodities as groundnuts, copra and palm kernels in the French colonies while entering into open competition with rival countries in the purchase and sale of oil nut and seed products. [E. J. B.]

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Blood-sucking Insects of Formosa. Part I. Tabanidæ (with Japanese species).—By Dr. T. Shiraki, Government Entomologist, Taihoku Agricultural Experiment Station, Formosa; 1918. 445 pages and 11 plates. (No price stated.)

THIS monograph of the Japanese species of Tabanidæ includes several that are recorded as found in India and Burma also, the following species being listed as occurring within Indian limits, viz., *Chrysops dispar*, *C. mlokosiewiczi*, *Tabanus sexcinctus*, *T. bicinctus*, *T. abbreviatus*, *T. indianus*, *T. crassus*, *T. sanguineus*, *T. fulvimedius*, and *T. birmanicus*, all of which are fully described and illustrated in the coloured and line plates. The descriptions are unusually full, covering sometimes eight pages of print, so that this book should be of considerable assistance to all engaged in work in Indian Tabanidæ. [T. B. F.]

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ANNUAL REPORT OF THE DISTRICT AGRICULTURAL ASSOCIATION OF BIRBHUM AND ITS BRANCH ASSOCIATIONS FOR 1919-20.

THE report begins with a general survey of the progress made since the main Association was constituted fifteen years ago. A new epoch in its short history began in the year 1918-19 when a realization of the difficulties of satisfactorily meeting the needs

of agriculturists scattered throughout the district set decentralization afoot. Rapid strides were made in the organization of Branch Associations to deal with smaller territorial units each comprising a *thana*, and, by the end of the year, 30 such associations were established. A steady growth in their development has continued, and their number has now reached 87. Each Association has 20 to 50 members, but some have as many as 150. Their work has spread into many channels bringing practical and visible benefits not only to their members but also to local cultivators in general. Some of their most noteworthy activities, worthy of emulation by similar associations in other districts, were the successful inauguration of useful schemes of re-excavation of irrigation tanks, construction of *bunds*, embankments and canals, consolidation of agricultural holdings, opening of agricultural night classes in Middle English Schools in different parts of the district and conservation of manures. We congratulate Mr. G. S. Dutt, I.C.S., under whose able guidance, as President, the Associations have made such healthy and commendable progress. [EDITOR.]

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

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1. Essays on Wheat, by Prof. A. H. R. Buller. Pp. xv+339. (London: Macmillan and Co., Ltd.) Price, 2·50 dollars.
2. Physiology of Farm Animals, by T. B. Wood and Dr. F. H. A. Marshall. Part I: General, by Dr. F. H. A. Marshall. Pp. xii+204. (Cambridge: At the University Press.) Price, 16*s.* net.
3. A Biochemic Basis for the Study of Problems of Taxonomy, Heredity, Evolution, etc., by Prof. E. T. Reichert. Part I. Pp. xi+376+34 plates. Part II. Pp. vii+377-834. (Washington: Carnegie Institution.)
4. A Text-book of Quantitative Chemical Analysis, by Dr. A. C. Cumming and Dr. S. A. Kay. Third Edition. Pp. xv+416. (London: Gurney and Jackson; Edinburgh: Oliver and Boyd, 1919.) Price, 12*s.* 6*d.* net.
5. Chemical Calculation Tables: For Laboratory Use, by Prof. H. L. Wells. Second Edition, revised. Pp. v+43. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1919.) Price, 6*s.* 6*d.* net.
6. Applied Economic Botany: Based upon Actual Agricultural and Gardening Projects, by Dr. M. T. Cook. (Farm Life Text Series.) Pp. xviii+261. (Philadelphia and London: J. B. Lippincott Co., 1919.) Price, 7*s.* 6*d.* net.
7. Agriculture and the Farming Business, by O. H. Benson and G. H. Betts. Pp. xvi+778. (London: Kegan Paul and Company, Limited, n.d.) Price, 10*s.* 6*d.* net.

THE following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Bulletins.

1. Notes on Practical Salt Land Reclamation, by G. S. Henderson, N.D.A., N.D.D. (Bulletin No. 91.) Price, As. 6.
2. Syngamus laryngeus in Cattle and Buffaloes in India, by A. Leslie Sheather, B.Sc., M.R.C.V.S., and A. W. Shilston, M.R.C.V.S. (Bulletin No. 92.) Price, As. 6.
3. A Preliminary Note on the Behaviour in North India of the first batch of Sugarcane Seedlings distributed from the Sugarcane-breeding Station, Coimbatore, by T. S. Venkatraman, B.A. (Bulletin No. 94.) Price, As. 8.

LIST OF AGRICULTURAL PUBLICATIONS IN INDIA FROM 1st AUGUST, 1919, TO 31st JANUARY, 1920.

GENERAL AGRICULTURE.

No.	Title	Author	Where published
1	*The Agricultural Journal of India*, Vol. XIV, Part V, and Vol. XV, Part I. Price Re. 1-8 or 2*s.* per part: annual subscription Rs. 6 or 9*s.* 6*d.*	Edited by the Agricultural Adviser to the Government of India.	Messrs. Thacker, Spink & Co., Calcutta.
2	Scientific Reports of the Agricultural Research Institute, Pusa (including the Report of the Imperial Cotton Specialist) for 1918-19. Price Re. 1-4 or 2*s.*	Issued from the Agricultural Research Institute, Pusa.	Government Printing, India, Calcutta.
3	Report on the Progress of Agriculture in India for 1918-19. Price Re. 1-4 or 2*s.*	Agricultural Adviser to the Government of India, Pusa.	Ditto.
4	Proceedings of the Board of Agriculture in India held at Pusa on the 1st December, 1919, and following days (with appendices). Price As. 12 or 1*s.* 3*d.*	Ditto	Ditto.
5	Notes on Practical Salt Land Reclamation, Pusa Agricultural Research Institute Bulletin No. 91. Price As. 6.	G. S. Henderson, N.D.A., N.D.D., Imperial Agriculturist, Pusa.	Ditto.
6	A Preliminary Note on the Behaviour in North India of the first batch of Sugarcane Seedlings distributed from the Sugarcane Station, Coimbatore, Pusa Agricultural Research Institute Bulletin No. 94. Price As. 8.	T. S. Venkatraman, B.A., Ag. Government Sugarcane Expert, Madras.	Ditto.
7	The Effect of Manuring with Superphosphate and Sannai on the Yield of Crops on Indigo Planters' Estates in Bihar—especially of Rabi Crops in the season 1918-19. Pusa Research Institute Indigo Publication No. 6. Price As. 6.	W. A. Davis, B.SC., A.C.G.I., Indigo Research Chemist, Pusa.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
8	Guide to Agricultural Section, Pusa. (*Not for sale.*)	Compiled by Agricultural Section, Pusa.	Government Printing, India, Calcutta.
9	Annual Report of the Board of Scientific Advice for India for the year 1918-19.	Issued by the Board of Scientific Advice for India.	Ditto.
10	Quinquennial Report on the Average Yield per Acre of Principal Crops in India for the period ending 1916-17. Price As. 12 or 1*s.* 2*d.*	Issued by the Department of Statistics, India.	Ditto.
11	Report on the Production of Tea in India in the Calendar Year 1918. Price As. 8.	Ditto	Ditto.
12	Estimates of Area and Yield of Principal Crops in India, 1918-19. Price As. 8.	Issued by the Department of Statistics, India.	Ditto.
13	Report on the Operations of the Department of Agriculture, Bengal, for the year 1918-19 (including Expert Officers' Reports). Price Rs. 2 or 3*s.*	Issued by the Department of Agriculture, Bengal.	Bengal Secretariat Press, Writers' Buildings, Calcutta.
14	Annual Reports of Expert Officers of the Department of Agriculture, Bengal, for the year 1917-18. Price Re. 1-12 or 2*s.* 6*d.*	Agricultural Department of Bengal.	Ditto.
15	Insect of Ganja, Bengal Department of Agriculture Bulletin No. 1 of 1919. Price A. 1.	Ditto	Ditto.
16	Annual Report of the Department of Agriculture, Bihar and Orissa, for 1918-19. Price As. 6 or 6*d.*	Issued by the Department of Agriculture, Bihar and Orissa.	Government Press, Bihar and Orissa, Patna.
17	Report on the Administration of the Department of Agriculture of the United Provinces for the year ending the 30th June, 1919. Price As. 8 or 1*s.*	Issued by the Department of Agriculture, United Provinces.	Government Press, United Provinces, Allahabad.
18	Report on the Agricultural Experiments in the Central Circle, United Provinces, for the year ending 30th June, 1919.	Ditto	Ditto.
19	Report on the Agricultural Stations of the Western Circle, United Provinces, for the year ending 30th June, 1919.	Ditto	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
20	Combined Report of the Partabgarh and Benares Agricultural Stations of the United Provinces for the year ending 30th June, 1919.	Issued by the Department of Agriculture, United Provinces.	Government Press, United Provinces, Allahabad.
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